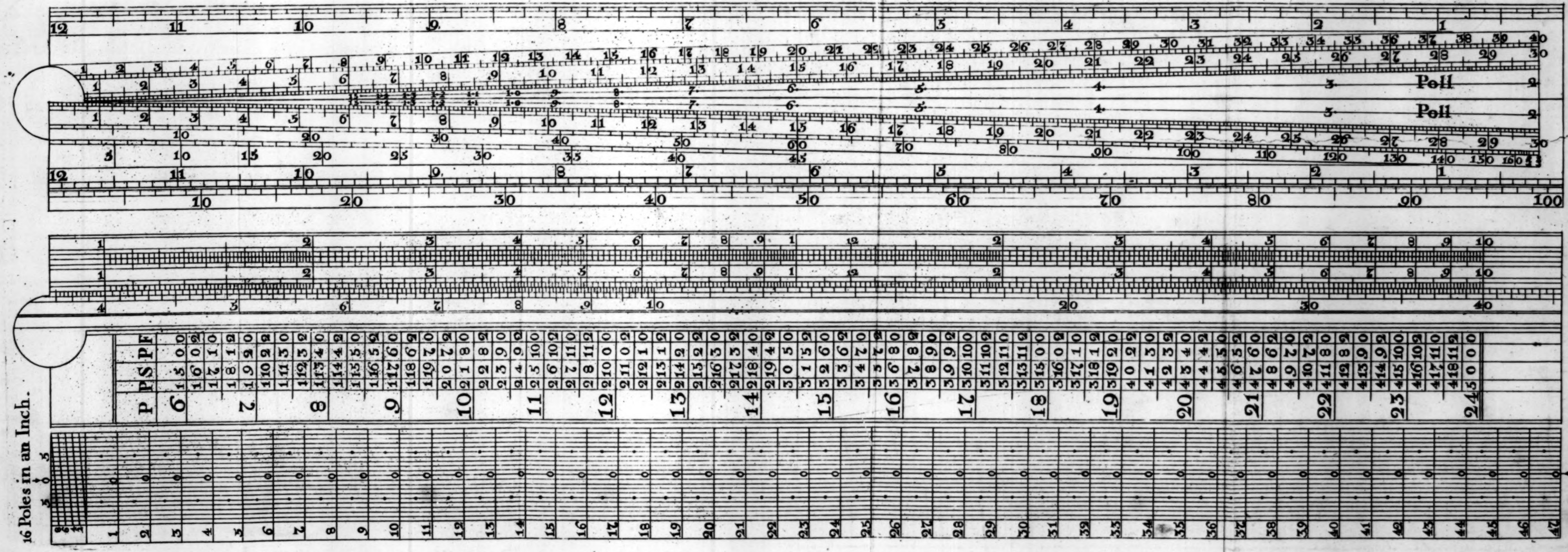


16 Poles in an Inch.

THE ART OF PRACTICAL MEASURING, BY THE SLIDING RULE:

Shewing how to measure

Round, Square, or other TIMBER,	GLASS,
STONE,	PAVING,
BOARD,	PAINTING, and WAINSCOT.

Also GAUGING; with Instructions in Decimals, Mr TOWNLEY's Method of the Logarithms, and the Use of the Diagonal Scale applied to *Gunter*'s Chain.

By HENRY COGGESHALL, *Gent.*

Whereto is added, in a Short Method,

The Use of SCAMMOZZI's Lines for finding the Lengths and Angles of Hips, Rafters, *&c.* at any Pitch, in Square, Bevelling, or Tapering Frames.

By JOHN HAM.

The SEVENTH EDITION, Carefully Corrected.

LONDON:

Printed for EDWARD and CHARLES DILLY, in the *Poultry*, near the *Mansion-House*.

MDCCLXVII.

THE

PREFACE.

THE general Approbation of this Treatise on the *Sliding-Rule* hath caused me to revise the Book. I have explained some Things, and added others, which I thought useful.

Whether Mr *Townley*'s Contrivance of the Indices be treated of any where but in Sir *Jonas Moore*'s Mathematical Compendium, I could never learn; nevertheless, the Extraction of the Square and Cube Roots of Decimals, according to that Contrivance, being there wanting, I have given it you here; so that the Root of a Decimal, whose Logarithm hath such an Index, is found with equal Ease as that of a whole Number.

I have shewn how to find the Logarithm to any Number of six Places,

 in

in Mr *Wingate's Tabulæ Logarithmicæ*, (omitted in the Explanation of the Tables) by the Differences at the Bottom, and a Slip of this Rule; it supplying the Place of a Table of proportional Parts, which adds much to the Usefulness of the said Book, in giving the Logarithm of any Number as far as a Million, with little Trouble.

The Gauging of Tuns is here shewn according to the modern Practice of Inching. I have given you a near Way of measuring a Solid that tapereth straight, as also of finding the total Content of the Conical Tun and Stand, from Mr *Everard*, whose Numbers for ten Inches Difference of Diameters, for the Parabola and Conoid, I have also inserted. Thus far Mr *Coggeshall*.

But in order to make this Treatise more acceptable, there are several Corrections, Emendations, and Additions made, particularly in shewing the Use of a new Three Foot Rule, which slides and shuts to a Foot, and which,

for the Sake of the Reader's Perusal, is neatly engraved upon a Copper Plate by that accurate Mathematical Instrument-maker Mr *Thomas Heath* in the *Strand*; for our Author's is entirely laid aside, as not being so complete; his making use of both Sides of the Rule in working Proportions, whereas this makes use but of one, which is not only a great Advantage in giving a Solution to all our Author's Propositions, but also reserves the other Side of the Rule for *Scamozzi*'s Lines; which are Lines known to most Workmen concerned in Buildings, to be of great Use in finding the Lengths and Angles of Hips and Rafters, and that by Inspection, when the Roof is true Pitch; and if otherwise, is here sufficiently illustrated by Schemes done from Copper Plates, there being an Example of a Frame that has the Gable End square, and the Bevel hipt; and another where both Ends bevel, and the Sides run taper; in which last is shewn a new Method of deter-

mining the Quantity of the Angles, eſpecially of thoſe which relate to the Back of the Hips, ſo that they may anſwer both Sides and Ends of the Roof; and laſtly, an Example of finding the Lengths of Rafters for the Gable End of a Houſe that bevels or lies out of ſquare, and the fitting in of the Purloins, and finding their Lengths.

Moreover, upon one Leg or Joint of the Rule there is a Table, with which, by Inſpection, you may know what a Load of Timber of 50 Feet will amount to, at any Price from 6*d.* to 2*s.* *per* Foot.

And if that which is here added prove uſeful, and render this Part of Building eaſy to Artificers in the Practice of their Buſineſs, it will be a Pleaſure to him, who upon all Occaſions is glad of promoting real and uſeful Knowledge.

JOHN HAM.

THE

CONTENTS.

SECT. I.

SECT. II. LOGARITHMS.

To

PART II.

PART III.

VIII. *Solids*

PART IV.

PART IV.

PART V.

5. *Having*

NEW BOOKS,

For the USE of SCHOOLS,

Printed for E. and C. Dilly in the Poultry,
Recommended by the Reverend Dr John Stirling.

THE New Spelling Dictionary, teaching to write and pronounce the English Tongue with Ease and Propriety. In which each Word is accented according to its just and natural Pronunciation; the Part of Speech is properly distinguished, and the various Senses are ranged in one Line; with a List of proper Names of Men and Women. The Whole compiled and digested in a Manner entirely new. To which is prefixed, A Grammatical Introduction to the English Tongue. By the Rev. John Entick, A.M. second Edition, Price 2s. bound. To which is now added, a List of all the Market Towns in England and Wales.

2. The whole Works of Horace translated into English Prose, as near as the Propriety of the two Languages will admit; together with the original Latin, from the best Editions, begun by David Watson, M.A. revised and carried on by Dr. Samuel Patrick, in two Volumes in Octavo, 10s. bound.

3. Terence's Comedies. Translated into English Prose, as near as the Propriety of the two Languages will admit. With the original Latin from the best Editions; wherein the Words of the Latin Text are ranged in their grammatical Order; the Ellipses carefully supplied; and the Observations of the most valuable Commentators, both Ancient and Modern, represented; and the Beauties of the Original explained in a new and concise Manner. With Notes pointing out the Connection of the several Scenes, and an Index critical and phraseological, To which is prefixed, The Life of TERENCE, with some Account of the Dramatic Poetry of the Antients. The Whole adapted to the Capacities of Youth at School, as well as of private Gentlemen

By SAMUEL PATRICK, LL.D.

Formerly Upper-Master at the Charter-house, London; and Editor of Ainsworth's Dictionary, and Hedericus's Lexicon. A New Edition, neatly printed in two Volumes, Octavo. Price Ten Shillings bound.

THE ART OF

PRACTICAL MEASURING.

PART I.

ALTHOUGH the way of Measuring by this Rule is so easy, that many, without the Art of Arithmetick, do understand and use it, as far as their particular Occasions require; yet it is convenient for a Measurer to have some Skill therein, especially in the five first Parts thereof.

There are Books of that Subject, written by divers, to be had at easy Rates, whereof only the later Authors treat of Decimal Arithmetick and Logarithms. By the former of these, the troublesome Way of working with the vulgar Fractions is avoided; by the other, Multiplication and Division are easily performed by Addition and Subtraction, and consequently the most useful Parts of Arithmetick are rendered far more easy and expeditious.

Both these, since they first came into use, have been improved. The four Rules in Division of Decimals, delivered by Mr *Wingate* in his first Treatises of Arithmetick, are by Mr *Kersey* reduced to one, which follows after; and Mr *Townley*'s Indices free the Operation by Decimals from Multiplicity of Rules, and give you the Rate or Value of them directly.

I have therefore here premised a short Treatise of Decimal Arithmetick, and of the Nature and Use of the Logarithms; noting first, that

the

the best way (in my Opinion) of reading Decimals, is, as you read whole Numbers, giving them the Value of the last Figure to the right Hand. To which purpose you may call them more easily, if instead of Tenths, Hundredths, Thousandths, Ten-Thousandths, &c. you say, Tenths, Cents, Millesms, Decimillesms, Centimillesms, Millemillesms, &c. as this .00165, I read thus, 165 Centimillesms; and so of any other.

SECTION I.

Notation, Addition, Subtraction, Multiplication, and Division in Decimals, also with whole or mixt Numbers.

A Decimal is the Numerator of a Fraction, whose Denominator is an Unit with one or more Cyphers; which Denominator is not expressed, it being known by the Numerator. For so many Places or Figures as are in the Numerator or Decimal, so many Cyphers are supposed to be adjoined to the Unit in the Denominator.

It ought to have a Point before it, as a Badge whereby it is known, being otherwise written as a whole Number: Therefore a Decimal of one place is Tenths, as this .2 is two Tenths; of two places is Hundredths, as this .02 is two Hundredths; of three is Thousandths, as this .002, &c. the significant Figures being put by the Cyphers into Places of less Value, and the Places decreasing from Unit in a ten-fold Proportion.

Or thus. Call such as have a significant Figure next after the Point, as these, .3, .25, .732, &c. Decimals of the first Rank or Rate. Such as have one Cypher after the Point, as these .08, .0134, &c. Decimals of the second Rank or

or Rate. Such as have two Cyphers after the Point, Decimals of the third Rate, *&c.* The Convenience whereof you will find afterwards.

The Work is the ſame as in the whole Numbers; yet take theſe Directions.

1. If you uſe a whole Number with mixt Numbers or Decimals, let it have always a Point after it.

2. In Addition and Subtraction, the Points prefixt to the Decimals muſt be ſet under one another, by which means the Units in the whole or mixt Numbers ſtand alſo under one another.

3. In Subtraction, although a Cypher at the right Hand of a Decimal is of no Value, as theſe, .5, .50, .500, are no more than 5 Tenths, or one half) yet if the Decimals conſiſt not of an equal Number of Places, or if one of the Numbers be a whole Number, you muſt annex Cyphers, or ſuppoſe them annexed.

Examples of Addition.

22.75	19.2	.17	32.78	.34
9.6	4.68	.89	12.	.178
				.84
32.35	23.88	1.06	44.78	.7
				2.058

Examples of Subtraction.

22.75	19.2	107.	48.16
9.6	4.68	8.93	17.
13.15	14.52	98.07	1.16

Multiplication.

1. But in Multiplication, ſet them as if they were whole Numbers, and ſo multiply them: Cutting off from the Product found ſo many Figures to the right Hand, as there are Places of Decimals, both in the Multiplicand, and the

 Multiplier;

Multiplier; ſo the Reſidue is the whole Part of the Product, and the Figures cut off, the Decimal.

2. If the Product hath not ſo many Places, as there are Places of Decimal Parts in both Numbers; ſupply the deficient Places with Cyphers prefixed to the left Hand.

Examples.

46.25	.87	564.	.0375	.76	.22
35.	.9	.25	.05	8.	.97
23125	.783	2820	.001875	6.08	1.54
13875		1128			
1618.75		141.00			

By theſe Examples you may ſee how the Whole Part of the Product is diſtinguiſhed from the Decimal Part thereof.

Diviſion.

In Diviſion it is ſomething harder to diſtinguiſh the Whole Part of the Quotient from the Decimal Part thereof.

Firſt, Annex Cyphers to the Dividend, at pleaſure, or leave Space for them, that the Diviſion may be continued to a ſufficient Quotient. Then place the Diviſor under it, according to the old way of Diviſion; but ſo as if they were both whole Numbers: Then obſerve well what Place or Degree of the Dividend ſtandeth over the Place of Units in the Diviſor; whether theſe Places be real, or only ſuppoſed; of the ſame Degree or Place is the firſt Figure in the Quotient. Which being once noted, you need not regard the Points nor Cyphers at either End of the Diviſor any more; but continue the Diviſion, as if both were whole Numbers.

See here the Degrees of Numbers as they ſtand

ſtand in their natural Order, which may be continued either Way from Unit.

Thouſ.	*Hund.*	*Tens.*	*Unit.*	*Tenths.*	*Hundreths.*	*Thouſandths.*
1000.	100.	10.	1.	.1	.01.	.001, &c.

I have here ſet down ſome Examples, wherein you may ſee how the Diviſor is placed under the Dividend at the firſt Queſtion, and alſo the two firſt Figures in the Quotient.

Divid. 180.000 (30. &c. *Divid.* 1.75000 (.02, &c.
Diviſ. 5.875 *Diviſ.* 63.
Divid. 1.00000 (.083, &c. *Divid.* .748000 (91. &c.
Diviſ. 12. *Diviſ.* .0082
Divid. 9.72000 (21. &c.
Diviſ. .45.

In the two laſt Examples; although there be neither Units Place in the Diviſor, nor (if there were) any Figure over it in the Dividend; yet by ſuppoſing the Places continued to the left Hand, or ſupplying them with Cyphers, you will ſee that the firſt Place in the Quotient is the Place of Tens.

I account that way of Diviſion the beſt, in which, after (upon Examination by multiplying the Diviſor by the anſwering Figure from the left Hand toward the right) you have found the fit Figure to be put in the Quotient; you proceed, in your Diviſion to multiply the Diviſor by the anſwering Figure, beginning with the Figure in the Diviſor next the right Hand. If the Figure over it in the Dividend be not great enough to take the Product out of it; call it ſo many Tens, more than it is, as will make it great enough, but no more; and then ſubtract; ſetting the remaining Figure over it, and cancel the ſaid Figure: And for the Tens added, call the Product of the next Figure ſo many Units more than it is. Admit the Product 36 muſt be

taken out of 2; call the 2, 42, and ſubtract. Suppoſe the next Product is 18; call it 22, &c. which Way you make feweſt Figures, and is no more Burden to the Memory than ordinary Multiplication.

To multiply or divide any Whole Number, mixt Number, or Decimal, by 10, 100, 1000, &c. *by removing the Point.*

To multiply: Remove the Point ſo many Places to the right Hand as there are Cyphers in the Multiplier: If Figures be wanting, ſupply them with Cyphers, as here, 2.7 by 10 is 27.: .13 by 100, is 13: 02 by 10, is .2.

To divide: Remove the Point ſo many Places to the left Hand, as there are Cyphers in the Diviſor: If Places be wanting, ſupply them with Cyphers, as here, 27. by 10 is 2.7.: .13 by 100, is .0013: .02 by 10, is .002.

SECT. II.

LOGARITHMS.

PUrpoſing to give you the Solution of ſome of the Queſtions in this Book by thoſe excellent Numbers the Logarithms; take theſe Directions for the better underſtanding the Nature and Uſe of them.

They are artificial Numbers, fitted to the natural, for the Eaſe of Calculation; and are printed in Tables having two Columns. One hath the natural Number; againſt it in the other are his Logarithms: So that the Logarithm of a Whole Number is eaſily found.

The Tables begin at 1, whoſe Logarithm is 0,00000; and reach commonly to 10,000; conſiſting every one of 8 Figures, though (unleſs in great Numbers) we ſeldom uſe above ſix; (if the

the Figures left out exceed 50, we put an Unit to the ſixth) to the Logarithms are annexed Differences; by the Help of which, and a Table of proportional Parts adjoined, you are directed to find the Logarithm of any Number to 100,000. But theſe are but of 7 Places.

Mr *Wingate*, in his *Tabulæ Logarithmicæ*, hath the Logarithms to 100,000, with Differences alſo; whereby making a Proportion, (which is done ſpeedily by one Slip of this Rule) you have the Logarithms as far as 1,000,000, in a portable Volume for the Pocket. A Book which I commend to any that delight in Arithmetick.

The firſt Figure, called the Index, (which is commonly ſeparated by a Point, better left out, except in the firſt Hundred, as in the late printed Tables) ſhews how many Figures the anſwering Number, if whole, or the whole Part thereof, if it hath a Decimal annexed, conſiſteth of; which are always more by one than the Index. So 0. is the Index of one Figure, 1. of two Figures, 2. of three, 3. of four, &c.

Alſo according to the excellent Way of Mr *Chriſtopher Townley*, cited by Sir *Jonas Moor* in his Mathematical Compendium, the Log. of a Decimal is the ſame as if it were a whole Number, with this Direction for the Index.

If the Decimal be of the firſt Rate, the Index is 9; if of the ſecond Rate, the Index is 8; if of the third Rate, the Index is 7, &c. that is, the Index of the Logarithm of any Decimal, wants as many Units of Ten, as the left Hand ſignificant Figure is diſtant from Unity: which, I hope, you will underſtand, if you obſerve this following Table.

Where you see, That in the perfect Numbers, the Index sheweth the Number of Places in the whole Numbers, and in the whole Part of the mixt, being always less by one than the said Places; but in Decimals it sheweth the Rate, being the Complement thereof to Ten, not regarding the Number of Places.

Perf. Numb.	*Log.*
3536.	3.54851
353.6	2.54851
35.36	1.54851
3.536	0.54851
Decimals.	*Log.*
.3536	9.54851
.03536	8.54851
.003536	7.54851
.0003536	6.54851

If then you would have the Log. of any Number, find the Log. thereof in the Table, as if it were whole; and prefix the Index answering the Value.

And having a Log. find the Number answering in the Table, and by a Point fix the Value according to the Index.

To find a Log. to a Number of six Places in the Tabulæ Logarithmicæ *by help of this Rule.*

Call the Difference at the Bottom the Tabular Differences. Having the Log. of the five first Figures, by the double Scale on your Rule, set 10 to the Tabular Differences; against your sixth Figure is his proportional Part to be added to the Log. before found.

To find a Number of six Places answering a Log. given.

Find the Number of five Places answering the Log. in the Table, next less to the given Log. subtract the said Log. out of the given Log. call the Remainder the proper Difference; then by the double Scale on your Rule, set 10 to the Tabular Difference; against the proper Difference on the second, is your sixth Figure on the first, to be annexed to the five Figures before found.

Note, That you must use all the eight Figures in these Cases.

Some Uses of the Logarithms.

Whereas, before the aforesaid Contrivance of the Indices by Mr *Townley*, if one Number were perfect, and the other a Decimal, there was a different Rule in every Operation for them; but by the said Contrivance one is now sufficient; I will give Examples only, in which one Number is a Decimal, with these two Directions.

1. In the Log. which answereth the Question, (whether it be a Sum, Remainder, Half, *&c.*) if the Index be ten, or above, neglect or cancel the said Figure in the Place of Tens.

2. Where you are ordered to subtract a greater Log. out of a less; add ten to the Index of the less, and then subtract.

1. *Multiplication.*

Add the Logs. of the two, or more Numbers to be multiplied; the Sum is the Log. of the Product. So 12 multiplied by the Decimal .25, the Product is 3.

12.	1.07918
By .25	9.39794
3.	10.47712

It may also be done where there are but two, by subtracting the Arithmetical Complement of the Log. of one of them out of the Log. of the other; the Remainder is the Log. of the Product.

Which Arithmetical Complement is the Remainder of every Figure, (including the Index) to 9; except of the last significant Figure to the right Hand, whose Remainder you must take to Ten. As in these three Examples.

Numb.		
2.	0.30103	*Log.*
.5	9.69897	*Ar. Compl.*
Numb.		
80.	1.90309	*Log.*
.0125	8.09691	*Ar. Compl.*
Numb.		
100.	2.00000	*Log.*
.01	8.00000	*Ar. Compl.*

2. *Division.*

Subtract the Log. of the Divisor out of the Log. of the Dividend, (whether of the two be greater or less) the Remainder is the Log. of the Quotient. So 12 divided by the Decimal .25; the Quotient is 48.

	12.	1.07918
By.	.25	9.39794
	48.	1.68124

It may also very conveniently be done, by adding the Ar. Compl. of the Log. of the Divisor to the Log. of the Dividend; the Sum is the Log. of the Quotient, as followeth.

3. *The Rule of Three Direct.*

1. Add the Logarithms of the second and third; from the Sum subtract the Log. of the first; the Remainder is the Log. of the fourth.

2. A better Way: Add the Ar. Compl. of the Log. of the first to the Logarithms of the second and third; the Sum is the Log. of the fourth.

Example If .25 give 16. What shall 12 give?

Answer, 768.

Ar. Compl.	.25	0.60206
	16.	1.20412
	12.	1.07918
	768.	2.88536

But in the inverse Rule: Add the Ar. Compl. of the Log. of the third to the Logarithms of the first and second; the Sum is the Log. of the fourth. Thus are resolved the Questions wrought on the double Scale.

But for those in this Book, where there is a duplicate Proportion, as in Timber Measure and Gauging, if the first and third Numbers be on the square Line, there are general or fixt Logarithms belonging to the first Numbers; to which if you add the Log. of the second, and the Log. of the third twice, the Sum of all four is the Log. of the fourth.

If the second and fourth Numbers be on the square Line; to the Ar. Compl. on the Log. of the first add the Log. of the third, and the Log.

of the second twice, half the Sum is the Log. of the fourth.

4. *The Square Root.*

Half the Log. of the Number given, is the full Log. of the Square Root.

If the Number be a Decimal,	.25	19.39794
add ten to the Index, and then	.5	9.69897
halve it, as here.		

5. *The Cube Root.*

The third Part of the Log. of the Number given, is the full Log. of the Cube Root.

If the Number be a Decimal,	.25	29.39794
add twenty to the Index, and	.63	9.72931
then divide by three, as here.		

6. *To find a mean Proportional between two Numbers.*

Add their Logs. together: Half the Sum is the Log. of the mean Proportional.

When one is a Decimal, if the	12.	1.07918
Sum of the Indices be ten, as here,	.25	9.39794
or above: cast away ten, and then		10.47712
halve it; if it be not ten, add ten	1.732	0.23856
to it, and then halve it.		

7. *To find two, or more mean Proportionals between two Numbers.*

This, in Case of a Decimal, was something perplexed, as you may see in Mr *Wingate*'s Artificial Arithmetick: It is now, by the aforesaid Contrivance of Mr *Townley* as easy as it is useful.

Subtract the Log. of the Less		
Number out of the Log. of the	12.	1.07918
greater: The Remainder divide	.25	9.39794
by a Number greater by one,		1.68124
than the Number of means		42031
sought; as here by 4 for three means.		

This

This Quotient added to the Log. of the leſs Number; the Sum is the Log. of the firſt Mean; to which adding again the ſaid Quotient, the Sum is the Log of the ſecond Mean. And ſo forward for as many Means, as the Quotient was at firſt ordered for.

		Means.
		9.39794
		42031
1	.658	9.81825
		42031
2	1.732	0.23856
		42031
3	4.556	0.65887

8. *To find the Log. of a Vulgar Fraction.*

Subtract the Log. of the Denominator out of the Log. of the Numerator, the Remainder is the Log. of a Decimal equivalent to the ſaid vulgar Fraction.

	0.47712
	0.60206
·75	9.87506

9. *To find the Log. of a Number with a Vulgar Fraction annexed.*

Suppoſe it to be $12\frac{1}{4}$; change the Number into an improper Fraction, by multiplying the whole Number by the Denominator of the Fraction, and adding the Numerator to the Product, the Sum is the Numerator of the improper Fraction.

$\frac{49}{4}$	1.69020
	0.60206
12.25	1.08814

Then ſubtract the Log. of the Denominator out of the Log. of the Numerator, as before; the Remainder is the Log. of the ſaid Number, with Decimals, equal to the ſaid vulgar Fraction annexed.

I have, as an Appendix to this Part, adjoined the uſual Decimal Tables, and compriſed them into five: Yet the Uſe of them is as eaſy as if they were all ſingle.

The Integers, or Wholes, are ſet on the Top; and the Parts follow in order, with their Decimals annexed.

TABLE

TABLE I.

A Table of English *Coin, a Pound Sterling, also Troy Weight, an Ounce* } *Integer.*

Shillings and Pennyweight.	Decimals.	Pence with Farthings.	Decimals.	Grains.	*The Residue of the Table.*		
					Pence with Farthings.	Decimals.	Grains.
19	·95	3	.0489582				
18	·9	2	.0479166	23			
17	.85	1	046875				
16	8	11	.0458333	22	5	.0208333	10
15	·75	3	.0447916		3	.0197916	
14	·7	2	.04375	21	2	.01875	9
13	65	1	.0427083		1	.0177083	
12	6	10	0416666	20	4	.0166666	8
11	55	3	.040625		3	.015625	
10	·5	2	.0395833	19	2	.0145833	7
9	·45	1	0385416		1	.0135416	
8	·4	9	.0375	18	3	.0125	6
7	·35	3	0364583		3	.0114583	
6	·3	2	0354166	17	2	.0104166	5
5	·25	1	.034375		1	.009375	
4	.2	8	.0333333	16	2	.0083333	4
3	.15	3	.0322916		3	.0072916	
2	.1	2	.03125	15	2	.00625	3
1	.05	1	.0302083		1	.0052083	
		7	.0291666	14	1	.0041666	2
		3	.028125		3	.003125	
		2	.0270833	13	2	.0020833	1
		1	.0260416		1	.0010416	½
		6	.025	12	½	.0005208	½
		3	.0239583				
		2	.0229160	11			
		1	.0218756				

TABLE

TABLE II.

Averdupois *great Weight, One hundred at 112l. Integer.*

Quarters.	Decimals.
3	·75
2	·5
1	25.
Pounds.	**Decimals.**
27	.2410714
26	.2321428
25	.2232143
24	.2142857
23	.2053571
22	.1964286
21	.1875
20	.1785714
19	.1696428
18	.1607143
17	.1517857
16	.1428571
15	.1339286
14	.125
13	.1160714
12	.1071428
11	.0982143
10	.0892857
9	.003571
8	.0714286
7	.0625
6	.0535741
5	.0446428
4	.0357143
3	.0267857
2	.0178571
1	.0089286

The Residue of the Table.

Ounces.	Decimals.
15	.0083705
14	.0078126
13	.0072545
12	.0066964
11	.0061384
10	.0055803
9	0050223
8	.0044643
7	.0039062
6	.0033482
5	.0027902
4	.0022321
3	.0016741
2	.0011161
1	.000558
Quarters.	**Decimals**
3	.0004185
2	.000279
1	.000125

TABLE III.

Averdupois *little Weight, one Pound* }
long Measure, one Yard or Ell, } *Integer.*

Ounces.	Decimals.	Qtrs. with Nails.
15	·9375	3
14	· 75	2
13	.8125	1
12	·75	3
11	.6875	3
10	.625	2
9	·5625	1
8	·5	2
7	·4375	3
6	·375	2
5	·3125	1
4	·25	1
3	.1875	3
2	.125	2
1	.0625	1

The Residue of the Table.

Drams.	Decimals.	Qtrs. of Nails
15	.0585937	
14	0546875	
13	0507812	
12	046875	3
11	.0429687	
10	.0390625	
9	.0351562	
8	.03125	2
7	.0273437	
6	.0234375	
5	.0195317	
4	.015625	1
3	.0117187	
2	.0078125	
1	.0032062	

Quarters.	Decimals.
3	.0029297
2	.0019531
1	.0009765

TABLE

TABLE IV.

Liquid Measure, one Gallon / *Dry Measure, one Quarter,* } Integ.

Pints.	Decimals.	Bush.
7	.875	7
6	.75	6
5	.625	5
4	.5	4
3	.375	3
2	.25	2
1	.125	1
Quarters.	**Decimals.**	**Pecks**
3	.09375	3
2	.0625	2
1	.03125	1
	Decimals.	**Qtrs. of a Peck**
	.0234375	4
	.015625	2
	.0078125	1
	Decimals.	**Pints**
	.0058594	3
	.0039063	2
	.0019531	1

TABLE V.

Dozens, or Gross / *Time, one Year,* / *Long Mea. 1 Foot* / *Pence, 1 Shilling.* } Integ.

Dozens Months	Decimals.	Inch. Pen.
11	.91666 7	11
10	.83333 3	10
9	.75	9
8	.6666667	8
7	.5833333	7
6	.5	6
5	.4166667	5
4	.3333333	4
3	.25	3
2	.1666667	2
1	.0833333	1
Parts.	**Decimals**	**Qtrs. and Fart.**
11	.0763889	
10	.0694444	
9	.0625	3
8	.0555555	
7	.0486111	
6	.0416667	2
5	.0347222	
4	.0277778	
3	.0208333	1
2	.0138889	
1	.0069444	

Days belonging to the Table of Time.

Days	Decimals.	Days.	Decimals.
30	.08219178	15	.0410959
29	.070452	14	.0383562
28	.0767123	13	.0356164
27	.0739726	12	.0328767
26	.0712329	11	.030137
25	.0684931	10	.0273972
24	.0657534	9	.0246575
23	.0630137	8	.0219178
22	.060274	7	.0191781
21	.0575342	6	.0164383
20	.0547945	5	.0136986
19	.0520548	4	.0109589
18	.0493151	3	.0082192
17	.0465753	2	.0054794
16	.0438356	1	.0027397

To bring Decimals into known Parts.

Multiply the Number of Parts in one Integer, and the Decimals together : From the Product cut off ſo many Figures to the right Hand as are in the Decimals (as you are directed in Multiplication of Decimals.) The Reſidue to the left Hand are the Parts ſought ; and the Figures cut off are a Decimal of one of thoſe Parts, to be reduced the ſame Way into the next leſs Parts, if there be any, or if there be need. If nothing be left to the left Hand, there is not one of thoſe Parts in that Decimal : Therefore account it cut off, and proceed to find the next leſs Parts, as before.

The making the foregoing Tables is by dividing the Numerator of the vulgar Fraction, which repreſents the Parts by the Denominator ; the Quotient is the Decimal. So $\frac{11}{20}$ being the vulgar

vulgar Fraction of eleven Shillings or eleven Penny Weights; if you divide 11 by 20, the Quotient .55 is the Decimal: So that half the Number of Shillings or Penny Weights is the Decimal. Also $\frac{26}{960}$ being the vulgar Fraction of 6*d.* $\frac{1}{2}$, or of 26 Farthings; if you divide 26 by 960, the Quotient .0270830, &c. is the Decimal.

Yet you shall not need Division for every Decimal; for some are found by halving the Integer or 1; and so continually: So are found the Decimal of one half, one quarter, one half quarter, &c. Some are found by halving a Decimal before found: So half the Decimal of a Shilling, is the Decimal of Six pence; half of that, the Decimal of Three-pence, &c. Also one third Part of the Decimal of a Shilling, is the Decimal of Four-pence; and the half of that the Decimal of Two-pence, &c. and the double of it the Decimal of Eight-pence. Likewise the Sum of two Decimals, is the Decimal of the Sum of the two Fractions, whose Decimals they are; and the Difference is the Decimal of their Difference.

Some of these are of one Place, and some of more: Few Tables have them to above seven; and most ordinary Questions may be resolved to a sufficient Exactness, if you use but four; remembring the Direction above given, *viz.* If the first Figure of those left out exceed 5, to add a Unit to the last of those you retain.

If the Answer of a Question be in Money, three Places of Decimals give it to near a Farthing, as is shewn after *Part* 4. *Prop.* 5.

Now for the Use of them in a Question or two.

1. At 5*s.* 3*d.* $\frac{1}{2}$ the Ounce; what cost 7 Ounces 3 Penny Weight, and 19 Grains?

Having

Having added the Decimals of the Parts, the Queſtion will ſtand thus:

ou.	*l.*		*ou.*	*l.*
1 :	0.2645833	: :	7.1895833 :	1.9022

The Product or Anſwer is 1*l.* 9022, *&c.* Which is 1*l.* 18*s.* 0*d.* 2*f.* near.

If you leave out the three laſt Figures in each Decimal, with the Conditions above-mentioned, the Numbers are,

ou.	*l.*		*ou.*
1 :	0.2646	: :	7.1896

And the Anſwer is 1*l.* 9023, *&c.* differing from the other inconſiderably.

2. To compute ſimple Intereſt for any Sum, Rate, and Time. Having put the Parts, if there be any, into their Decimals; multiply the Principal and the Rate; from the Product cut off the due Decimal, if any, and two Places for the Diviſion by 100: This Product ſo ordered is the Intereſt due for one Year; which if you multiply by the Time, (be it more or leſs than a Year) the Product (the due Decimal cut off) is the Intereſt for that Time.

Examp. 1. What is the ſimple Intereſt of 132*l.* 7*s.* 6*d.* for 2*y.* 3*m.* 22*d.* at 6*l.* in the Hundred?

The Decimal of 7*s* 6*d.* is .375; which being annexed to the whole Pounds, the Principal will be 132*l.* 375; which multiplied by 6, and the Product ordered as directed, it will be 7.9425, or 7*l.* 18*s.* 10*d.* 1*f.* near, for the Intereſt for one Year. But that not being the Sum ſought, multiply the ſaid 7.9425 and the Time, *viz.* 2*y.* 3103, the Product 18.3493 is the Intereſt ſought, *viz.* 18*l.* 6*s.* 11*d.* 3*f.*

Ex. 2.

Ex. 2. What is the Intereſt of the ſaid Sum for two Months and ten Days at the ſame Rate? Multiply the ſaid 7.9425 by .1941 the Decimal of the Time, the Product 1*l.* 5416, or 1*l.* 10*s.* 10*d.* is the Intereſt ſought.

But the great Convenience of Decimals is, that their Logs. are ſo eaſily found; as is already ſhewn in this ſecond Section. So that by the *Tabulæ Logarithmicæ*, mentioned in the aforecited Place, any Queſtion, whoſe Numbers (whether Whole, Mixt, or Decimals) exceed not ſix Places, may be ſpeedily reſolved: Mr *Townley*'s Indices of the Decimals freeing us from Perplexity of different Rules. As in the two laſt Examples.

To the Arith. Com. of the Log. of 100, *viz.* 8.0000000 add the Log. of the Principal, and of the Rate; the Sum is the Log. of the Intereſt for one Year. To which Log. if you add the Log. of the Time, this Sum ſhall be the Log. of the Intereſt for the Time.

Example 1.

100. *Ar. Com.*	8.
132.375	2.1218052
6.	0.7781512
79.2425	0.8999571
2.3103	0.3636683
18.3495	1.2636254

Example 2.

100. *Ar. Com.*	8.
132.375.	2.1218059
6.	0.7781512
.1941	9.2880255
1.5416.	0.1879826

Or without ſeeking the Intereſt for one Year. To the ſaid Ar. Compl. add the Logs. of the Principal, Rate, and Time, the Sum ſhall be the Log. of the Intereſt demanded, as in the ſecond Example.

3. Compound Intereſt for any Principal, Rate, and Time by the Logarithms.

In

In this Propoſition the Excellency of thoſe Numbers appear; ſuch Queſtions being reſolved by them with great Eaſe and Speed; but by natural Arithmetick not without conſiderable Time and Trouble.

Deduct the Log. of 100 from the Log. of 100, and the Rate added together, as 105, 106, &c. The Difference multiply by the Time: From the Product cut off the Decimal, if there be any: The Remainder add to the Logarithm of the Principal; the Sum is the Logarithm of the Principal and Intereſt required.

Example.

Let the Principal, Rate, and Time be as in the former of the two laſt Queſtions. Purſuing the Rule, as you ſee in the Margin; the Sum of the Principal and compound Intereſt is 151*l.* 9*s.*

The Difference		253058
The Time		2.3103
The Product		584639.8974
	132.375	2.1218059
		584639
	151.45	2.1802698

It ſeems by this, that the Intereſt of 100*l.* at 6*l. per Cent.* by the Year, is not fully amounted to 3*l.* in ſix Months; for if you multiply the aforeſaid Difference by 5, the Decimal of ſix Months; and, having cut off one Place, add the Reſidue to the Log. of 100, the Sum will be 2.0126529; which is the Log. of 102.956, that is 102*l.* 19*s.* 1*d.* 1*f.*

I will add two or three Examples more, which, I hope, will be ſufficient.

1. What is the Value of 28 Ounces, ſix Penny Weights and 15 Grains of Gold, at 3*l.* 3*s.* 6*d.* the Ounce? Annexing the Decimals to the Integers, the Numbers ſtand thus:

an

	ou.	*l.*	*ou.*	*l.*
	1 :	3.175 : :	28.33125 :	89.52

l.	*s.*	*d.*	*f.*		
Facit, 89 .	19 .	00 .	2	3.175	0.5017437
				28.33125	1.4522657
				89.952	1.9540094

	ou.	*p.*	*gr.*		*l.*	*s.*	*d.*
2. If	4	9	12	of Gold cost	14	10	9;

What is that the Ounce?

	ou.	*l.*	*ou.*	*l.*
The Numbers are	4.475 :	14.51875 : :	1 :	3.2444

l.	*s.*	*d.*	*f.*			
				4.475	*Ar. Com.*	9.3492070
Facit, 3	04	10	2	14.51875.		1.1619291
				3.2444.		.5111361

3. At 6*s.* 3*d.* the Ounce; how much Silver Plate will 5*l.* 3*s.* 6*d.* buy?

	l.	*ou.*	*l.*	*ou.*
The Numbers are	0.3125 :	1 : :	5.175 :	16.56

ou.	*p.*	*gr.*			
			.3125	*Ar. Compl.*	0.50515
Facit, 16	11	05 near.	5.175		0.71391
			16.56		1.21906

I have taken but six Figures in this last Example. If I had used no more in the other, the Difference would have been little or inconsiderable; as you may find, if you please to give yourself that small Trouble.

These thus premised, I shall come next to the Description and Uses of the Rule in several Measures; wherein I shall use these vulgar Fractions, *viz.* ¼ one Quarter, ½ one Half, ¾ three Quarters: The Decimals belonging to these, as they are immediate Parts of the Whole, are .25 for a Quarter, .5 for an half, and .75 for three Quarters.

But

But if they be Parts of Parts, other Decimals belong to them, as you see in the Tables.

PART II.

The Description of the Rule.

THIS Rule is different from that described by Mr *Coggeshal*, and which was all along made use of in the former Editions, but now is laid aside, as not being so complete; for his made use of both Sides of the Rule in working Proportions, whereas this makes use but of one: which is not only a great Advantage in the Performance of the Operations, but also reserves the other Side for the Lines made use of in *Scamozzi's* Architecture, for the ready finding the Lengths and Angles of Rafters, *&c.* Of which more in its proper Place.

Therefore in *Fig.* I. to give a Description of that Side of the Rule, which gives a Solution to all Mr *Coggeshall's* Propositions, there is a Piece made to slide in and out, having on each Edge thereof a Line of Numbers in two Lengths, *viz.* from 1 at the Beginning to 1 in the Middle, which is esteemed one Length; and from 1 in the Middle to 10 at the End, the other.

There are also adjoining to this Piece two Lines, on one Side, a Line of Numbers in all Respects like those just described; and on the other, a Line figured 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, called the Square Line, and when the Measure of round Timber is concerned, the Girt Line.

The

The Lines of Numbers on the ſliding Piece and that adjoining thereto, are divided between 1 and 2 into 10 Parts, and each Tenth into 5 Parts; between 2 and 3 into 10 Parts, and each Tenth into 2 Parts; from 3 to 4, and from 4 to 5 it is the ſame; from 5 to 6 into 10 Parts only; and ſo on to 1 in the Middle. The ſecond Length or Radius is divided exactly like the firſt.

The Girt Line from 4 to 10 has each Tenth divided into 2 Parts, and from 10 to 40 each Whole into 4 Parts; alſo the Diviſions 37, 38, and 39, with their Halfs and Quarters, are put on before 4 at the Beginning of this Line, and cut, as in their proper Places, towards 40 at the other End of the Line; from whence the Diviſions are carried on to 45, each Diviſion between 40 and 45 being divided into two Parts.

There is upon the ſame Side of the Rule, but upon the other Leg, a Table, whereby you may know, by Inſpection, what a Load of Timber will amount to at any Price between *6d.* and *2s.* *per* Foot, reckoning 50 Feet to the Load.

Example 1.

At *9d. per* Foot, a Load of Timber will come to *1l. 17s. 6d.*

Example 2.

At *10d.* ¼ *per* Foot, a Load will amount to *2l. 2s. 8d.* ½.

When the Rule is opened, ſo as to become one right Line, you will find that the Back or outer Edge thereof is decimally divided; that is, each Foot is divided into 10 equal Parts, and each Part into 10 more, by which means the Rule is divided into 200 equal Parts; and with this Line I mean Dimenſions ſhould be taken, when I ſpeak of Foot Meaſure.

Next to this outer Edge, on the other Side of the Rule, where *Scamozzi*'s Lines are, is a Line of Inches decimally divided, and consequently each Inch is divided into 10 equal Parts, which is for Gauging.

Note, On the Back-side of the sliding Piece is a Foot Rule, whose Inches are divided into Halves, Quarters, and Half-Quarters.

That Line of Numbers upon the sliding Rule, with that Line of Numbers which is next to it on the fixed one, is in this Book called the double Scale.

SECTION I.

Of the Line of Numbers, commonly called Gunter's *Line.*

The proper Numeration of this Line I account, 1 at the Beginning; and so by 10 in the Middle, to 100 at the End.

But for the better understanding this Line, see here the Degrees of Number from Unit on either Side, as they stand on the Line; that is, increasing from left Hand to right.

Thous. pts.	*Hund. pts.*	*Ten. pts.*	*Unit.*	*Ten.*	*pts. Hund*	*Thou.*
.001	.01	.1	1.	10.	100.	1000.

Where you see, how they increase on one Side from Unit, and on the other Side decrease from the same in a tenfold Proportion. So that if you set any one of them at the Beginning, the two next following shall be, one the Middle, the other the End. As if you call 1 at the Beginning one tenth, the Middle shall be 1, and the End 10. If you call one at the Beginning 10, the Middle shall be 100, and the End 1000. But if it be not otherwise limited, account it, as I said before, 1, 10, 100.

On that Line of Numbers which is on the moveable Rule, at these Numbers following may be Pricks, for the more ready finding them; they being first Numbers, or Centers, as they commonly call them.

At 9 for Yard Measure. .

At 12 four Points thus . . for Plank or Board, and Glass. . .

At 144 also for Glass.

At 160 for Land Measure.

At 272, 25, or 272 for Rod Measure of Brick-work at 1 ½ Brick thick; for the Decimal .25 equal to ¼ may be omitted without considerable Error.

At 204 for two Bricks thick, and other Points or Cuts for other Thicknesses, if desired. The finding whereof is shewed after.

At 282 for Ale-Gallon Measure in square and oblong Vessels. And others may be supplied, as any hath occasion for them.

SECTION II.

Of the Square or Girt Line.

THIS is no more but one whole Length of the Line of Numbers, but at a double Radius, it being exactly equal to the Lines of Numbers on this Rule, which are in two Lengths.

In the Numeration of it, when occasion requires, you must account 10, 20, 30, to be 1, 2, 3; as also 4, 5, 6, 7, *&c.* to be 40, 50, 60, 70, *&c.*

At 12 on this Line let there be four Pricks, as at 12 on the Line of Numbers: At 17.15, the Wine Point, marked W. At 18.95, the Ale Point, marked A. These are put on by the Workman.

At 10.635 may be a Point like the Gauge Points, for finding the true Content of a round Solid by the Girt.

At 13.54 ſuch another, for finding the Content of a Cylinder by the Diameter.

At 41.57 another, to ſhew how many Inches in Length make a Foot Solid at any Girt or Square not exceeding 40 Inches.

Theſe may be put on thus:

For the firſt: Set 12 on the Square Line to 14 on the Line of Numbers; againſt 11 on the Line of Numbers mark this Point.

The ſecond: Set 12 on the ſquare Line to 11 on the Line of Numbers; againſt 14 on the Line of Numbers mark this Point.

The third: Set 12 on the ſquare Line to 1 at the Beginning of the Line of Numbers; againſt 12 on the Line of Numbers mark this Point.

Theſe, or any other mentioned hereafter, cut with a ſharp-pointed Penknife in two Places, as the Gauge Points, and ſtrike in with your Finger ſome Sallow Coal fine ground with Linſeed Oil, and then wipe the Rule clean.

Both theſe Lines are put on from the Logarithms.

SECT. III.

The general Uſe of double Scales.

IT is chiefly for the working the Rule of Three, or having three Numbers given, to find a fourth Proportional, it including Multiplication and Diviſion; for there is no other Difference, than that in theſe two an Unit is one of the three.

To find this fourth: Set the firſt Number on the ſliding Rule to the ſecond on the Line of Numbers on the fixed Rule; againſt the third

Number on the firſt of theſe Rules, is the fourth on the ſecond Rule.

Example. If 2 give 3, what ſhall 6 give? Set 2 on the firſt to 3 on the ſecond; againſt 6 on the firſt is 9 on the ſecond.

Wherefore when I ſay, ſet 2 to 3, againſt 6 is 9, I mean as in the above-ſet Example, tho' I name not the firſt or ſecond Rule, yet you may note that the moveable Rule is for the moſt Part the firſt.

So in Multiplication, 1 being the firſt Number, ſet one to either of the two Numbers to be multiplied, (beſt to the neareſt) againſt the other is the Product.

In Diviſion, the Diviſor being the firſt Number, ſet it either to one, or to the Dividend, againſt the other is the Quotient. Examples of both you will meet with after.

By this the Arithmetick of the Rule is eaſily underſtood, the firſt Numbers being Diviſors; only where the ſquare Line is uſed, the Numbers on the ſquare Line muſt be ſquared or multiplied by themſelves, and their Squares uſed in every reſpect as if they were the Numbers themſelves, as you will after ſee.

SECT. IV.

To ſet the ſquare Line to his Squares, and thereby to ſquare a Number not exceeding 100, *and to find the ſquare Root of a Number not exceeding* 10,000.

1. SET 10 on the ſquare Line to 1 at the Beginning of the Line of Numbers, both which, if you account 1, you have on the Line of Numbers the Squares from 1 to 20. Alſo at this ſet as is moſt convenient to take the Squares from 100 to 2000, *viz.* by accounting 10 on the ſquare Line 10, and 1 at the Beginning 100.

2. Set 10 on the ſquare Line to one in the Middle, accounting 10 on the ſquare Line 10, and 1 in the Middle 100, you have the Squares

on the Line of Numbers from 16 to 1000; and of this you will have moſt Uſe.

3. Set 10 on the ſquare Line to 10 at the End, accounting 10 on the ſquare Line 100, and 10 at the End 10,000; ſo have you on the Line of Numbers the Squares from 1400 to 10,000; and againſt all the Squares, at every Set, his own Root upon the Square or Girt Line.

Example. I would know what is the ſquare Root of 380?

Set 10 on the ſquare Line to one in the Middle, (according to the ſecond Direction) againſt 380 on the Line of Numbers is 19.5 near.

SECT. V.

A Direction concerning the Shortneſs of the Lines on the Rule.

1. IN working theſe Proportions on the double Scale, if you uſe half of either the ſecond or third Number inſtead of the whole, you will have half the Content; if you uſe the Half of both, you have only a Quarter of the Content. *Note,* The firſt Number muſt always remain whole.

2. On the ſquare Line: If you uſe half that Number that is on the Line of Numbers, commonly the ſecond, (being ordinarily Lengths or Depths) you have half the Content.

If half of that on the ſquare Line, commonly the third, (being ordinarily Sides of Squares, or Diameters) you have a Quarter of the Content; if you halve them both, you have only one Eighth of the Content.

3. In finding a mean Proportional; half the Extremes give half the Means, and a Quarter gives a Quarter. Theſe may be more exactly defined, and multiplied accordingly.

This Direction alſo may be uſeful to you in working by the ſquare Line, when at any Time the third Number ſtandeth beyond the Line of Numbers; and removing the firſt to the ſecond

in the other Length, sets it farther off. For then,

1. If the first be a fixed Number on the square Line, as 12, and the Gauge Points, &c. set it to half the second, and double Content.

2. If the first and second be fixed, as in finding the superficial Content by the Diameter, use half the third Number being on the square Line, and quadruple (or multiply by 4) the Content.

These Products are the 4th Numbers sought.

PART III.

PROP. I.

To measure round Timber the common Way.

MEasure the Length in Feet and half Feet, and (if the Custom or Agreement be so) in Quarter; then back again half way, where girt the Tree with a small Cord or Chalk-Line, double this Line twice very even. This fourth Part of the Circuit, (which in this Treatise I call the Girt) measure in Inches, halves and quarters of Inches. And this observe, that the Lengths be given in Feet, the Girts and Sides of Squares in Inches.

So have you three Numbers given, *viz.* 12 always the first, the Length always the second, and the Girt or Side of the Square the third.

To come now to the Rule: Set 12 on the Girt Line to the Length on the Line of Numbers; against the Girt on the Girt Line is the Content on the Line of Numbers. And this is the general Rule.

Now there being two Cases, one when at the first Set the Girt is against some Part of the Line of Numbers, the other when it is not, so that

12 must be removed; I will give you several Examples of both, observing that the vulgar Fractions before-mentioned, as also all Decimals, always follow the Number they belong to before the Name thereof.

CASE I.

EXAMPLES.

1. A Tree is 20 Foot long, and 15 Inches girt, set 12 to 20, against 15 is 31 $\frac{1}{4}$ Foot, or 31 Foot and a Quarter.

2. A Length is 8 $\frac{1}{2}$ Foot, the Girt is 35 $\frac{3}{4}$ Inches; set 12 to 8 $\frac{1}{2}$, against 35 $\frac{3}{4}$ is 75 Feet and almost an half.

3. A Length is 15 Foot, the Girt 42 $\frac{1}{2}$ Inches; set 12 to 15, against 42 $\frac{1}{2}$ is 188 Foot.

4. A Rail is 15 Foot long, the Girt 3 Inches; set 12 to 15, against 3 is 9 Tenths of a Foot, and more.

5. A Length is 9 $\frac{1}{2}$ Foot, the Girt 39 $\frac{3}{4}$ Inches; set 12 to 9 $\frac{1}{2}$, against 39 $\frac{3}{4}$ at the Beginning of the Girt Line is 104 Foot.

6. The Length is 0 62 Foot, the Girt 35 Inches, set 12 to the Decimal .62 in the first Length, against 35 is 5 $\frac{1}{4}$ Foot, which may serve for a short Cut of a Tree.

If this Length had been propounded 7 $\frac{1}{2}$ Inches, it must have been turned into Foot Measure thus: On the double Scale set 12 on the sliding Rule, to 100 on the Line of Numbers on the fixed Rule; against the Length in Inches is the Length in Foot Measure, equal to 625 of a Foot; but if it lies before you, measure it by the Line of Foot Measure on the Rule.

CASE II.

If at the first Set the Girt is beyond the Line of Numbers, remove 12 to the Length in the

other Length thereof. Which Caſe may alſo happen in Gauging, &c.

Example 1. The Length is 18 Foot, the Girt 31 Inches; ſet 12 to 18 in the firſt Length, againſt 31 is 120 Foot.

2. A Rail is 15 Foot long, the Girt 3 ½ Inches; ſet 12 to 15 in the firſt Length, againſt 3 ½ is ¼ Foot, and a little more, *viz.* 1.27 Foot.

A Wrong is 6 ½ Foot long, and 4 ¼ in Girt; ſet 12 to 6 ½ in the ſecond Length, againſt 4 ¼ is above eight Tenths of a Foot. Theſe Examples may be ſufficient.

Note 1.

If you would find the Content of a great Piece of Timber immediately in Loads, at 40 Foot to the Load, uſe half the Girt inſtead of the whole. *Example.* A Length is 15 Foot, the Girt 42 ½ Inches; ſet 12 to 15, againſt 21 ¼ is 47, whereof the 4 is 4 Loads, and the 7 is 28 Foot.

If by this Way you meaſure Timber, whoſe Girt is above 40 Inches, as alſo the Piece in *Caſe* 1. *Ex.* 5. which, without the ſaid Subdiviſions, and placing 38 and 39 before 4 at the Beginning, are not reſolved by the general Rule.

But if you would have the Content of theſe Pieces in Feet, multiply the Content found by 4, the Square of 2, by which you divided your Girt; ſo 47 multiplied by 4 is 188 Foot.

Note 2.

To what Length ſoever you ſet 12, 17 will ſtand to the Double thereof, 8 ½ to Half thereof, both a little over; alſo 24 will ſtand to the Quadruple thereof, and 6 to a Quarter thereof exactly; and the ſame Proportion the Content bears to the Length at any of theſe Girts, *viz.* at 17 Inches Girt, the Content is double to the Length;

Length; at 8 ½ Inches Girt, the Content is but half the Length, &c.

Note 3.

If you would find these Contents by natural Arithmetick, seeing 12 and the Girt, *viz.* the first and third Numbers, are on the square Line, according to a Hint given in *Sect.* 3. of *Part* 2. multiply the Square of the Girt by the Length, and divide the Product by 144, the Square of 12, which is your constant Divisor, the Quotient is the Content.

So in *Ex.* 1. *Case* 1. the Square of 15, *viz.* 225, multiplied by 20, and the Product 4500, divided by 144, the Square of 12, the Quotient is 31.25, the Content.

By the Logs. to this general Log. 7.84164, add the Log. of the Length and the Log. of the Girt twice; the Sum is, The Log of the Content.

Gen. Log.		7.84164
	20	1.30103
	15	1.17609
		1.17609
	31.25	1.49485

PROP. II.

True Measure of round Timber or Stone by the Girt.

BEcause this common Way of measuring round Timber giveth not a true Content, but always too little, (though it still be generally used) I have given you a Point, and shewn how you may put it on the Rule, which setting to the Length instead of 12, the Girt shall point you out a true Content, accounting it a Cylinder, as the said common Way also doth.

Example. Let the Length be 10 Foot, the Girt 15 Inches; set the said Point marked at 10, 635 on the Square or Girt Line (which you may call the true Point) to 10; against 15 you have 20 Foot less by about one Tenth; where-

as the common Way giveth but 15 Foot, and a little above an Half.

The general Logarithm anſwering this Point is 7.94652, to be uſed as before.

Thus far by the Length and Girt: I ſhall only add, that the common Meaſure is to the true as 11 to 14; ſo that if you ſet 11 on the double Scale to any Number of Feet or Loads meaſured the common Way, 14 ſhall point to the true Content of the ſame; and if you ſet 14 to any true Content, againſt 11 is the Content of the common Way.

PROP. III.

Having the Length of a Cylinder in Feet, and the Diameter in Inches, to find the Content in Feet.

SET the Point 13.54 to the Length, againſt the Diameter is the Content. *Example.* Let the Length be 10 Foot, and the Diameter 20 Inches, ſet 13.54 to 10, againſt 20 is 21,82 Foot; the general Log. is 7.73676, to be uſed as before.

PROP. IV.

Having the Length of a ſquare Solid in Feet, and the Side of the Square in Inches, to find the Content in Feet.

SET 12 to the Length, againſt the Side of the Square is the Content. The Caſes are as in round Timber; the Examples alſo will ſerve, accounting the Girts to be Sides of Squares.

PROP. V.

To find a mean Proportional between two Numbers.

SET the greater of the two Numbers on the ſquare Line to the ſame on the Line of Numbers, againſt the leſs on the Line of Numbers is the mean Proportional on the ſquare Line.

Or ſet the leſs on the ſquare Line to the ſame on the Line of Numbers, againſt the greater on the Line of Numbers is the mean Proportional on the ſquare Line. One of theſe will not fail. Examples follow in the next.

PROP. VI.

Unequal ſquared Solids.

MEaſure the Length in Feet, the Breadth and Depth in Inches; then find a mean Proportional between the Breadth and Depth, as is taught above; and it will be the Side of a Square equal to the Baſe or End; which having found, meaſure the Piece as ſquare Timber.

Example 1. In Timber, whoſe Length let be 10 Foot, the Breadth 21 Inches, the Depth 8 ½ Inches; ſet 21 to 21, againſt 8 ½ on the Line of Numbers is 13.36, or 13 a Quarter and half Quarter near; or ſet 8 ½ to 8 ½, againſt 21 on the Line of Numbers is the ſaid 13.36; then ſetting 12 to 10, againſt 13.36 is 12.4 Foot.

Example 2. In Stone, which let be 6.35 Foot long, 36 ½ Inches broad; and 5.7 Inches deep; ſet 36 ½ to the ſame, againſt 5.7 on the Line of Numbers is 14, and ſomething ſhort of an half; then ſet 12 to 6.35, againſt this Mean is 9.2 Foot near.

This Mean, in Caſe of a Fraction, ſhall give you no Trouble; for if with a Pencil, Chalk or any thing that may be wiped out without Damage to your Rule, (let it not be Ink) you make a fine Mark on the ſquare Line at this Mean, and then ſet 12 to the Length, this Mark, without defining it, ſhall point out your Content.

PROP. VII.

Solids of a Triangular Baſe.

FIND a mean Proportional between the Baſe and half the Perpendicular, or between the Perpendicular

Perpendicular and half the Baſe, both meaſured in Inches; this Mean is the Side of a Square equal to the Triangle; then ſet 12 to the Length in Feet, againſt this Side is the Content.

If two Sides of a Triangle be equal, the unequal Side may be the Baſe; if the three Sides be unequal, the longeſt Side is commonly the Baſe; from whence the neareſt Diſtance to the oppoſite Angle is the Perpendicular.

PROP. VIII.

Solids whoſe Baſes have many equal Sides and equal Angles.

THESE Baſes are regular Figures: Having the Length in Feet, and a Side in Inches, get the Perpendicular from the Center to a Side alſo in Inches; ſo ſhall the mean Proportional between the Perpendicular and half the Sum of the Sides be the Side of a Square equal to the Baſe; which having found, meaſure it as ſquare Timber.

Example. A Piece of Timber of eight Sides is 10 Foot long, the Side 12 Inches, the Perpendicular 14.48 Inches, which you may call $14\frac{1}{2}$; ſet $14\frac{1}{2}$ to $14\frac{1}{2}$, againſt 48, half the Sum of the Sides on the Line of Numbers, is 26.4 on the ſquare Line, or there make a Mark; then ſet 12 to 10, againſt this Mark is 48 Foot, and a little more than a Quarter.

And thus much of theſe Ways of Timber Meaſure, which being the main Occaſion of the Rule, and not depending on any thing which followeth, I have ſet in the firſt Place.

PROP. IX.

Having the Girt, to find the Side of the Square equal near.

THIS and the two following Propoſitions are wrought on the double Scale, yet I have

here

here adjoined them for their Affinity with Timber Meaſure, and the proportional Numbers given in them are ready cut on the Rule, and give Contents to an Exactneſs ſufficient in any Concerns of Timber.

As 7. to 7.9, ſo the Girt to the Side of the Square equal: Let the Girt be 15 Inches on the double Scale, ſet 7. to 7.9, againſt 15 is 16.9 near: If you ſet 12 to the Length in Feet, this Side ſhall point out a true cylindrical Content.

PROP. X.

Having the Girt, to find the Side of the Square within near.

AS 10 to 9, ſo the Girt to the Side of the Square within near. *Example.* Set 10 to 9, againſt 15 is $13\frac{1}{2}$; and ſo much will ſuch a Piece bear ſquare.

By which you may know, before a Piece be hewn, how many whole Boards or Planks, of any Thickneſs, may be had out of it.

From hence alſo you may ſee, that the Girt, tho' leſs than the Side of the Square equal, yet is greater than the Side of the Square within; toward which, moſt Timber is hewn before it can ſerve to any ſquare Uſes: which may be one Reaſon of the Continuance of the ſaid common Way; of which Opinion I find alſo Mr *Henry Philips* to be, in a Treatiſe on this Subject.

PROP. XI.

Having the Diameter, to find the Side of the Square within near.

AS .1 to .707, or to excuſe a Cut there, as 8.5 to 6, (being Points equivalent near) ſo the Diameter to the Side of the Square within near.

Let

Let the Diameter be 19.1, *viz.* the Diameter of 60 Inches Circumference; set 8.5 to 6 against 19.1 is near 13.5 near.

PROP. XII.

To find how many Inches in Length make a Foot Solid, at any Girt or Side of Square not exceeding 40 Inches.

SET the Girt or Side of the Square on the square Line to 1 at the Beginning of the Line of Numbers, against 41.57 are the Inches which make a Foot.

So if you set 6, for Example, to 1, against 41.57 is 48, and so many Inches in Length make a Foot at six Inches Girt or Side of Square.

And now having done with the Measure of ordinary Timber, let me advertise any Reader that hath not seen much measured, that sometimes he will find a great Difference in the Girt of a Tree in the Space of a Foot, more or less, for the most Part where one or more Arms have been cut off; in such Case it is necessary to girt the Tree twice, nay thrice, if there be Cause, otherwise there will be Loss to Buyer or Seller.

Also they say, the Buyer hath Privilege to girt any where between the Middle and the Ground End, if it be for his Advantage.

PROP. XIII.

True Measure of a Solid that tapereth straight.

MEasure the Length in Feet; note also the third Part, which you may find by setting 3 on the double Scale to the Length; against 1 is the third Part. If the Solid be round, measure the Diameters at each End in Inches; subtract the less Diameter out of the greater; half the Difference add to the less Diameter; the

the Sum is the Diameter in the Middle of the Piece.

1. Set the 13.54 to the Length, against the Diameter in the Middle is a fourth Number.

2. Set 13.54 to the third Part of the Length, against half the Difference is a fourth Number; both these fourth Numbers added together make the Content.

Example. Let the Length be 18 Foot, the third Part is 6; let the greater Diameter be 24, the less 16, the Difference is 8; half the Difference 4 added to the less Diameter 16, the Sum 20 is the Diameter in the Middle.

Set 13.54 to 18, against 20 is 39.27.	39.27
Set 13.54 to 6, against 4 is .524, which	.524
added to 39.27, maketh 39.794, or 39 Foot and above 3 Quarters.	39.794

Note, That 13.54 must be set to 6 in the second Length, as in the second Case of round Timber-Measure the common Way.

If the Solid be square, use the Sides of the Squares at each End in every Respect as the Diameters, measuring them in Inches, *&c.* but let 12 be your first Number.

If it be any other regular Figures, use the Sides of the Squares equal to each Base (found as is before shewn) as the other, taking also 12 for your first Number.

PROP. XIV.

The Measure of a Shell or Flitch of Timber.

IF a Piece be taken out of the Middle of a round Piece of Timber from End to End, there will be left two Pieces which they call Shells or Flitches.

To find a near Content of these after the common Way with little Trouble, measure the Length in Feet, the round Part, and the Thickness in the Middle (taken with a Pair of Calepers) in Inches. These

These two, with a third Part of the Thickneſs, add together; a fourth Part whereof account your Girt, and meaſure as round Timber the common Way.

If on the double Scale you ſet 3 to 4, againſt the Thickneſs is itſelf, with a third Part added to it.

Example. Let the Length be 30 Foot, the round Part 25.3 Inches, the Thickneſs 7.2 Inches; ſet 3 to 4, againſt 7.2 is 9.6, which added to 25.3, maketh 34.9, the fourth Part whereof is 8.7 near.

Or prick the ſaid 9.6 on the flat Part in the Middle from one Side, and keeping the End of your Line at the other, girt the whole round Part, and to the ſaid Prick; double the Line twice, and meaſure it in Inches for your Girt.

Set 12 to 30, againſt 8.7 is 15 Foot and three Quarters.

Note, That this holds not ſo well in Sections cut far from the Middle of the Piece; in others it giveth a Content ſomewhat leſs than the common Way, which may the better be borne with, becauſe there is more Loſs in theſe than in other Pieces; and as they fall ſhort of the middle Pieces in Value, ſo a leſs exact Meaſure may ſerve.

PROP. XV.

Having the Diameter, to find the Area or ſuperficial Content of the Circle.

SET 1 on the ſquare Line to .7854, or to excuſe a Cut there, ſet 11 to 9.5, againſt the Diameter is the ſuperficial Content.

Example. Let the Diameter be 1.7 Foot, ſet 11 to 9.5, againſt 1.7 is 2.27 Foot near.

By

By the Logs. to the Log. of the Diameter twice add this Log. 9.89509, being the Log. of the Decimal .7854, the Sum is the Log. of the superficial Content.	1.7	0.23045 0.23045
	.7854	9.89509
	2.27	0.35599

Note, That if the Diameter exceed not 3.57, 1 in the Middle is but one; but if it exceeds 3.57, 1 in the Middle is 100.

Here you may have occasion to make use of the Direction given in *Sect.* 5. *Part* 2.

Hence it is as easy, having the superficial Content, to find the Diameter, or to cast any Number into a Circle, so may the Gauge Points be put on; for they being the Diameters of Circles, whose Areas are equal to the Number of Cubick Inches in the Gallon of Wine or Ale respectively, if you set the Rule as above, you will see the Wine Point stand against 231, and the Ale Point against 282.

PROP. XVI.

Cask Gauging.

THE Figures of these Vessels being uncertain, the Staves of some being more circular from Head to Bung, and so more capacious than other, the late Gaugers distinguished them into four Kinds; the Sphæroid, whose Staves are most arching, and this contains most; the Conick, whose Staves from Head to Bung are strait, (if any such can be made) and this contains least; the Parabola, whose Staves are arching, but nearer to the Sphæroid than to the Conick; the Conoid, whose Staves are arching, but nearer to the Conick than to the Sphæroid; all these may have the same Dimensions of Length and Diameters, yet differ considerably in the Contents.

Mr *Everard* in his excellent Piece, *Stereometry made easy*, printed 1684, giveth a Diagram of all the Kinds and Rules for each, both by Arithmetick and the sliding Rule, except for the Conick, there being (as he saith) none such made; yet the Figure thereof is useful to the distinguishing the other.

Mr *Wingate* took no Notice of these several Kinds; his general Way applied to this Rule is thus:

Measure the Length of the Vessel within the Diameter at the Bung, and the Diameter at the Head in Inches and Tenths, subtract the Diameter of the Head out of that of the Bung, the Difference multiply by 7, and divide the Product by 10 on the Rule easily thus; on the double Scale set 10 to the Difference, against 7 is the Quotient, which is 7 Tenths of the Difference.

These added to the less Diameter, the Sum is an æquated Diameter.

Then set the Gauge Point, whether of Wine or Ale, to the Length, against the æquated Diameter is the Content in Gallons.

Mr *Everard* agreeth with Mr *Wingate* upon 7 Tenths near for ten Inches Difference of Diameters, and accounts them to the Sphæroid; in other Differences of Diameters they differ more.

His Numbers for 10 Inches Difference are; for the Sphæroid 7.01, for the Parabola 6.39, for the Conoid 5.62.

In other Differences the Rule differs something from his Table, to which I refer you.

To find the Content of a Cask in all these Kinds; let the Length be 34.5, the Diameter at the Bung 29.4, that at the Head 25.3, this deducted out of that at the Bung, the Remainder or Difference is 4.1.

Set

Set 10 to 4.1, against 7 is 2.87 for the Sphæroid; against 6.39 or 6.4 is 2.62 for the Parabola; against 5.62 is 2.3 for the Conoid.

These added severally to 25.3, the Sum is 28.17 for the Sphæroid, 27.92 for the Parabola, 27.6 for the Conoid, for æquated Diameters.

Example. Set the Ale Point to 34.5, against 28.17 is 76.25 Gallons for the first; against 27.92 is 74.9 Gallons for the second; against 27.6 is 73.2 Gallons for the third; such is the Difference (upon account of their Shape) by these Numbers.

By the Logs. to this general Log. 7.53148 for Wine, to this 7.44484 for Ale, add the Log. of the Length, and the Log. of the æquated Diameter twice, the Sum is the Log. of the Content, as you see here for Wine.

Gen. Log.	7.53148
34.5	1.53782
28.17	1.44979
	1.44979
93.08	1.96888

The Fractions are thus reduced to Pints; on the double Scale set 10 to 8, against the Decimal are the Pints answering.

The Spheroid may be known by the round swelling of the Staves from one Head to another. If you lay a straight Rule on the Hoops of a Cask from the Head towards the Bung, and it toucheth, or very near, the Hoop next the Head, and that next the Bung, you may account it a Conoid; if the Rule librate upon the middle Hoops, like the Beam of a Balance, and yet the Staves not much swelling, account it a Parabola.

Besides the Shape of these Vessels, I have observed two Things, not noted by any to my knowledge, which may render the gauging them uncertain; one is, the joining Staves of unequal

Thickness,

Thickneſs, not taking care to ſmooth them within, which may cauſe an Error of ſome Tenths in taking the Bung Diameter.

The other this; the Head Diameter may be taken too great, tho' taken without, by reaſon of the paring away, and ſmoothing the inward Side of the Caſk at each End, in order to the putting in the Heads; ſo that in reaſon it ſhould exceed the Diameter pointed out by the Staves, which is the true Diameter: Both theſe I have ſeen in Caſks that have been cut aſunder.

PROP. XVII.

Gauging and Inching of Tuns.

THESE are of ſeveral Figures, but moſt are ſquare or round.

The ſquare are either equal ſided or unequal, both right-angled, and may be conſidered as the ſame.

The round are either cylindrical, *viz.* having the Diameters at Top and Bottom equal (if any ſuch can be hooped;) or conical, whoſe Diameters at the Top or Bottom are unequal.

Alſo the Content may be required, either total, or only of ſome Liquor contained in them.

The Content is ordinarily found firſt in Ale Gallons, which are reduced to Beer Barrels, by dividing the Number of Gallons by 36, or to Ale Barrels, by dividing the ſame by 32; alſo a Barrel containeth 4 Firkins; ſo 9 Gallons of Beer, 8 Gallons of Ale make a Firkin; the Dimenſions, *viz.* Lengths, Breadths, Depths, and Diameters, are taken in Inches.

SECT. I.

Square Tuns.

ON the double Scale ſet 282 (cut on theſe Rules) to either Length or Breadth, againſt the

the other is the Content in Gallons at 1 Inch deep, which being reduced to Firkins and Barrels, as it will bear, by a continual Addition, as we add Pounds, Shillings, and Pence, a Table may be made to any Number of Inches deep.

Or if you ſet 1 on the ſaid Scale to any Depth in Inches of this Content, againſt the other is the total Content; or multiply them by the Pen.

Example. The Length is 84 Inches, the Breadth 62 Inches, ſet 282 to 62, againſt 84 in the firſt Length is 18.47 Gallons, or 2 Firkins, 2 Gallons, and near an half of Ale, which you may add, as in the Margin.

In.	*B.*	*F.*	*G.*	*Pts.*
1	0	2	2	47
2	1	0	4	94
3	1	2	7	41
4	2	1	1	88
5	2	3	4	35
6	3	1	6	82
7	4	0	1	29

Let the Depth be 26 Inches. ſet 8 to 18.47, againſt 26 is 480.22, which is near a Quarter.

By the Logs. To this general Log 7.54975 add the Logs. of the Length and Breadth, the Sum is the Log. of the Content at 1 Inch deep; and if to this you add the Log. of the Depth, the Sum is the Log. of the whole Content; or if to the ſaid general Log. you add the Logs. of the Length, Breadth, and Depth, the Sum is the Log. of the whole Content, without Notice of the Content, at 1 Inch deep.

Gen. Log.	7.54975
84.	1.92428
62.	1.79239
18.47	1.26642
26	1.41497
480.2.	2.68139

Becauſe it is likely there will be Tenths of an Inch wet, on the double Scale ſet 10 to the Content in Gallons at 1 Inch deep, againſt every Tenth is his own Share, or Part of the ſaid Gallons. Let the Tenths be 6, ſet 10 to 18.47, againſt 6 is 11 Gallons, belonging to 6 Tenths. They put no Pints into the Table.

SECT.

SECT. II.

Cylindrical Tuns.

Having the Diameter of a cylindrical Tun in Inches, to find the Content in Ale Gallons at 1 Inch deep.

IF the Diameter exceed not 40 Inches, set the Ale Point to 1 in the Middle, against the Diameter is the Content, 1 in the Middle being one Gallon.

If the Diameter be above 40 Inches, set the said Point to 10 at the End, against the Diameter is the Content, 1 in the Middle being 10 Gallons.

Which Contents, being for 1 Inch deep, may be first reduced, and then added continually for a Table; or before it be reduced, multiplied by the Depth for a total Content.

Or set the Ale Point to the Depth, against the Diameter is the total Content.

Example. Let the Diameter be 58 Inches, set the Ale Point to 10 at the End, against 58 is 9.37 Gallons, the Content at 1 Inch deep; let the Depth be 36 Inches, set the said Point to 36, against 58 is 337.3 Gallons; or multiply the Depth and Content at 1 Inch deep by the Rule or Pen.

By the Logs. To the gen. Log. for Ale, add the Log. of the Diameter twice, the Sum is the Log. of the Content at 1 Inch deep.

And if you use the Log. of the Depth, as in the former Section you will have the whole Content.

	Gen. Log.	7.44484
58.		1.76343
		1.76343
9.37		0.97170
36.		1.55630
337.3		2.52800

SECT.

SECT. III.

Conical Tuns.

1. TO find the whole Content; proceed as in the Measure of a Solid that tapereth strait, *Prop.* 13. only measure the Depth also in Inches, and instead of the Point at 13.54, use the Ale Point, as also the general Log. used in the Section next above, which belongeth to it.

2. But in order to inching them; in small ones and Keelers, they use only the Diameter in the Middle, and account them as Cylinders; but in the larger they take one in the Middle of every ten Inches, (beginning at the Bottom) as also in the Middle of the remaining Inches, except they be few, for then they account them to the last ten, and take the Diameter in the Middle; these Tens also they account as Cylinders.

3. Having found the Content answering the Diameter next the Bottom, as is shewn *Sect.* 2. put it into Firkins and Barrels, as it will bear, and by a continual Addition (as in *Sect.* 1.) make up the said ten Inches.

Then add the Content answering the next Diameter so reduced, Inch by Inch to the last Sum, and so proceed till you have finished.

4. In a regular Tun; having the Diameters at Top and Bottom, and the perpendicular Depth, you may find any intermediate Diameter thus.

Divide the Difference of Diameters by the Depth, the Quotient multiply by any Distance from the greater Diameter, and subtract the Product from the said Diameter, the Remainder is the Diameter at that Distance; or multiply the Quotient by any Distance from the less Diameter, and add the Product to the said Diameter, the Sum is the Diameter at that Distance.

5. If the Tun be not exactly round, measure two Diameters where you observe the Inequality; add them together, and take the half; let the said two Diameters be the longest and shortest, which will cross one another near at right Angles.

6. Because most large Tuns are fixed, and that dripping, for the better Descent of the Liquor, the square ones for the most part cornerwise, and the Crowns or Bottoms of the round ones commonly uneven and irregular; I advise you to fill up the said Crowns or Bottoms, as also the Crowns of Coppers, by Measure, till they be wholly covered.

Which may be done by a Vessel of known Quantity, or you may gauge one or a Pail, or by a true Gallon, (for making which Directions are after given, which may also be otherwise serviceable) or in large Tuns best of all by both Vessel or Pail and Gallon, using the Vessel first, and when near covered, the Gallon.

7. When the Bottom is covered, assign the gauging Place, (where the Water covers a whole Inch, if it may be; if not, make it up by Measure) and fix it by a Mark, and note the wet Inches; mark also the Ends of the Diameters at the Superficies of the Water, as also the Perpendicular, or nearest Distance of the Top of the Staff from the Water, where the Distance is least, and the Length of the Staff from the Water in the same Place; of all which having taken an exact Account, let out the Water, and from the aforesaid Marks begin the Measure of your several 10 or 12 Inches, and to the Quantity before measured in, add your Contents Inch by Inch; the Content will be exact enough, if you take a Diameter in the Middle of every 12 Inches.

8. These several 10 or 12 Inches being understood

derſtood to be of the perpendicular Depth, to avoid an Error, which in ſome Caſes may be conſiderable, on the double Scale ſet the perpendicular Depth to the Length of the Staff; againſt any Number of the ſaid Depth is the Number anſwering on the Staff, which is always greater than that of the Depth.

9. The proportional Parts of any Content belonging to any Diameter, found as before, are to be ſet down, every Part againſt its own Tenth, in a Column by themſelves, againſt the Contents of the whole Inches, to be uſed for the Parts, which for the moſt part happen to be over and above the whole Inches.

10. Reduce not the Decimals of a Gallon (the Addition of them being eaſy, and becauſe they make not their Table to Pints) except in the proportional Gallons.

11. The Diameters, whether long or ſhort, are meaſured by ſliding Rules, numbered in Inches as they are drawn out, (or in Gallons, which will ſave you ſome Trouble) and are made to ſet together (ſo as to be portable) to a great Length.

What hath been ſaid of theſe Tuns, may be underſtood of Coppers, Coolers, or any other Veſſels uſed for Wort, either round or ſquare.

12. In an oval Tun; find a mean Proportional between the longer and ſhorter Diameter, it is the Diameter of a Circle equal to the Oval.

13. As for a true Gallon; to any Diameter in Inches which you chuſe, find the Content in Inches, (as *Prop.* 15.) by which divide 231 or 282 for Wine or Ale reſpectively, the Quotient found to the hundredth Part of an Inch, is the Depth.

Example. The Diameter is 6 Inches. The ſuperficial Content anſwering is 28.27, by which dividing 231, the Quotient is 8.17,

the Depth of the Wine Gallon; by which again dividing 282, the Quotient 9.97 is the Depth of the Ale Gallon.

If you would have it ſquare, divide the ſaid two Numbers by the Square of the Side in Inches; let the Side be 5 Inches, by 25 divide 231, the Quotient 9.24 is the Depth of the Wine Gallon; and again, by 25 divide 282, the Quotient 11.28 is the Depth of the Ale Gallon.

PROP. XVIII.

To gauge a Stand.

IT may be accounted a cloſe conical Tun, and meaſured as a Solid that tapereth ſtraight, *Prop.* 13. only (as in the conical Tun) meaſure the Depth alſo in Inches, and inſtead of the Point 13.54 uſe the Gauge Points, and the general Log. belonging to them; as in this Example in Ale.

Let the Depth be 33 Inches, a third Part thereof is 11; let the greater Diameter be 30 Inches, the leſs 24 Inches, the Difference is 6, the half Difference 3, which added to the leſs Diameter, the Sum 27 is the Diameter in the Middle.

1. Set the Ale Point to 33, againſt 27 is 67 Gallons.

2. Set the ſaid Point to 11, againſt 3 is 27, or about a Quarter of a Gallon; ſo the Content of the Stand is 67.27 Gallons.

So little is the Difference between the exact Content, and that found by the Diameter in the Middle.

PROP. XIX.

To enlarge or diminiſh a Circle, Square, or other regular Figure, at a Rate given.

THE Proportion (reſpecting the Rule) is, as one Term of the Rate to the Square of the Diameter

Diameter or Side given, ſo the other Term to the Square of the Diameter or Side required; therefore the Root thereof is the Diameter or Side demanded.

Alſo if you would enlarge, the leſs Term of the Rate is firſt; if you would diminiſh, the greater is firſt.

Example 1. If 1000 Men lodge in a Square whoſe Side is 60 Paces, how many Paces ſhall the Side of a Square be wherein 5000 Men may ſo lodge?

Here the ſecond Number being on the firſt or moveable Rule, it is moſt convenient to ſet 60 on a ſquare Line to 1000 in the Middle of the Line of Numbers, againſt 5000 on the Line of Numbers is about 134, and ſo many Paces muſt the Side be.

Example 2. I would diminiſh a Circle whoſe Diameter is 10 Foot, at the Rate of 8 to 5; ſet 10 on the ſquare Line to 8 on the Line of Numbers, againſt 5 on the Line of Numbers is 7.9 Foot, the Diameter required.

PROP. XX.

Having the Dimenſions of the Parts of a Ship, which make the Faſhion or Shape, together with the Burden thereof, to find the Dimenſions of the ſaid Parts for a Ship of any other Burden, greater or leſs, retaining the Faſhion or Shape of the given Ship.

THIS Propoſition I find in Mr *Norwood*, but wrought with great Trouble. Since the Invention of the Logarithms by the Lord *Napier*, (whoſe Name will never be forgotten) it is performed with great Eaſe, either by the Line of Numbers, with a Cube Line, being a Line of a triple Radius adjoined, or moſt exactly by the Logs. for want of the aforeſaid

Cube Line, take this way by Compasses on the Line of Numbers.

Divide the Space between the Burden given and that required into three equal Parts, with this Extent, set one Foot of the Compasses on each of the given Dimensions, *viz.* the Length of the Keel, Length of the Midship Beam, and Depth of the Hold, *&c.*

And if the Burden required be greater than that given, turn the other Foot forward to a greater Number; if less, turn it backward to a less Number, and they will be the respective Dimensions required in Feet and Tenths.

EXAMPLE.

The Burden given 100 Tun. Required 280 Tun.

	F.	*F.*
Length of the Keel	50.5	71.2
Len. of the Midship-beam	21.	29.6
Depth of the Hold	9.	12.7
Raking forw. of the Stem	13.5	19.
Raking backw. of the Stern	4.	5.6

By the Logs. subtract the Log. of the less Burden from the Log. of the greater, the Difference divide by 3; the Quotient or third Part add to or subtract from the Logs. of the several Dimensions of the given Ship, according as the Burden required is greater or less than the given; the Sums or Remainders shall be the Logs. of the Dimensions for the Burden required.

This, holding true in the Dimensions of Masts, Yards, Cables, Anchors, *&c.* must needs be of great Use, being so easily wrought, especially to the Shipwright, it freeing him from gross Errors; and by it he may be instructed to provide and order his Materials to the best Advantage.

To Gauge a Cask which is not full.

A TABLE for gauging of Wine Casks which are not full.

G.	parts	G.	parts	G.	parts	G.	parts	G.	parts
0	000	13	2630	26	4330	39	5913	52	7672
1	295		2703		4400		5976		7758
2	470	14	2775	27	4462	40	6040	53	7829
1	602		2847		4542		6094		7909
	720	15	2918	28	4585	41	6158	54	7990
2	830		2986		4646		6223		8072
3	935	16	3056	29	4706	42	6288	55	8154
	1038		3123		4766		6353		8236
4	1138	17	3189	30	4826	43	6418	56	8319
	1235		3255		4885		6483		8404
5	1329	18	3321	31	4943	44	6548	57	8491
	1420		3387		5000		6613		8580
6	1502	19	3452	32	5057	45	6679	58	8661
	1596		3517		5115		6745		8765
7	1681	20	3582	33	5174	46	6841	59	8862
	1764		3647		5234		6877		8962
8	1846	21	3712	34	5294	47	6944	60	9065
	1928		3777		5354		7012		9170
9	2010	22	3842	35	5415	48	7082	61	9280
	2091		3906		5476		7153		9398
10	2171	23	3960	36	5535	49	7225	62	9530
	2242		4024		5600		7297		9705
11	2328	24	4087	37	5662	50	7370	63	10000
	2405		4154		5724		7444		
12	2481	25	4213	38	5787	51	7519		
	2556		4270		5850		7595		

The Use of the TABLE.

FIND the Content of the whole Caſk, and the Depth of the Liquor therein, being the wet Part of the Bung Diameter, the Axis of the Veſſel being horizontal or level; as the Diameter at the Bung in Inches to the Depth of the Liquor, ſo 10,000, the Radius of the Table, to the proportional Part; find in the Table the ſaid Parts, or neareſt, and note the Gallons and Parts anſwering; then as 63, the Gallons in a Wine Hogſhead, to the Gallons noted, ſo the Content of the whole Caſk to the Content of the Liquor in the Caſk.

PART IV.

The Uſe of the double Scale of Numbers in ſome ſuperficial Meaſures and Accounts.

Directions.

1. IN the Rule of Three direct. If the ſecond Number be greater than the firſt, the fourth ſhall be greater than the third; and on the contrary.

But in the inverſe Rule, if the ſecond be greater than the firſt, the fourth ſhall be leſs than the third; and on the contrary.

2. If ſetting the firſt to the ſecond, the third reacheth beyond the Line, either remove the firſt to the ſecond in the other Length of the ſecond Line, or take the third Number in the other Length of the firſt Line.

3. The ſecond and third Numbers are never taken both on the ſame Line.

4. Obſerve well what Number goeth with the Queſtion; for in the direct Rule, that of the other two which agreeth with it in Name or Reſpect,

Reſpect, is the firſt, which you may ſet to either of the other.

As, if the Queſtion be: If 32 Bricks pave one ſquare Yard, how many Bricks will pave 12 Yards? Here 12 is the third Number, and 1 the firſt, (both being of a Name) which ſet 12 or 32, againſt the other is 384 Bricks; but for the moſt part the firſt Numbers are given, as you will find after.

5. It is not hard to know the Value of the fourth Number, for every Number on the Line increaſing or decreaſing in a tenfold Proportion, the Nature of the Queſtion or the Thing meaſured will diſcover it; as in the Example above, the fourth Number may be 384, or 38.4, or 3.84; but it is evident that it cannot be either of the two latter, much leſs 3840; ſo is it in any other.

PROP. I.

Multiplication, 1 *being the firſt Number.*

Sect. 1. *The Square.*

Multiply the Side by itſelf; let the Side be 14 Foot, ſet 1 to 14 (beſt in the firſt Length) againſt 14 on the firſt is 196 Foot. This is alſo found on the ſquare Line.

Sect. 2. *The long Square.*

Qu. 1. Multiply the longer Side by the ſhorter. A Wall is 30 $\frac{1}{2}$ Foot long, and 16 Foot high; ſet 1 to 16, againſt 30 $\frac{1}{2}$ is 488 Foot.

Qu. 2. A Length is 42 Foot, the Breadth $\frac{3}{4}$ Foot; ſet 1 to 42, againſt the Decimal .75 is 31 $\frac{1}{2}$ Foot.

Qu. 3. How many Men are in a Body, where they ſtand 18 in Front, and 8 deep? Set 1 to 8, againſt 18 is 144.

Sect. 3. *The Triangle.*

Multiply the Base and Perpendicular, the one whole by half the other, which you will. In the Pike End of an House, the over-way is 18 Foot, the Distance from the Pike to the over-way (being the Perpendicular) 16; set 1 to 8, against 18 (as before) is 144 Foot; or set 2 to either Perpendicular or Base, against the other is the Content.

Sect. 4. *The Trapezium.*

It is an irregular four-sided Figure. An irregular Plot (as of Land) before the Content can be found, is divided into these Trapezia and Triangles.

To find the Content, draw a Line from one Corner to his opposite one through the Trapezium, so as (if it may be) the two Perpendiculars falling from the other two Angles upon this diagonal Line (as they call it) may fall within the Trapezium; yet if one falls without, the Rule holds, but then the said diagonal Line must be produced far enough.

So have you two Triangles having one common Base; multiply this Base by half the Sum of the Perpendiculars, the Product is the Content of the Trapezium; or set 2 to the Base, against the Sum of the Perpendiculars is the Content.

There is a Trapezium much used by the best Surveyors of Land, who, when they measure against a crooked Limit, (be it Hedge, Ditch, or River) carry their Chain strait from Mark to Mark, and taking Perpendiculars from the Chain to the Bents, Nooks, or Windings of the Limit, describe Trapezia's in their Plot, having each two parallel Sides, and two right Angles.

The

The Content is found by multiplying half the Sum of the parallel Side (being the Perpendiculars) by the nearest Distance between them, being the intercepted Part of the said Chain Line; the Product is the Content.

So is measured any Trapezium which hath two parallel Sides, tho' the Angles be not right; but then one Side must be continued, if need be, for this Line of nearest Distance must be perpendicular to the parallel Sides.

Thus may the Rhombus and Rhomboid be measured, and infinite others, neither æquilateral nor æquiangular.

Sect. 5. *Any regular Figure*,

Whose Sides being equal, the Angles are also equal; multiply half the Sum of the Sides by the Perpendicular let fall from the Center to one of the Sides.

Example. A Table hath 6 Sides, each Side 2 Foot, the Perpendicular 1.73 Foot; set 1 to 1.73, against 6 is 10.4 Foot.

Sect. 6. *The Circle, and his Parts.*

1. The superficial Content hereof is best found by *Prop.* 15. *Part* 3. It is also found by multiplying half the Circumference by the Semidiameter.

2. For the Semi-circle, multiply half the Arch-Line by the Semi-diameter

3. The Sector, which is any Part contained between two Semi-diameters and the Arch-Line, is also measured the same Way.

4. If a straight Line be drawn through a Circle, not through the Center, it divides the Circle into two Segments; the Measure of the less is thus: Measure the Sector, whereof the Seg-

ment is a Part, then ſubtract the Content of the triangular Part, the Remainder is the Content of the Segment; but in the greater Segment the Content of the included Triangle muſt be added.

5. Having the Chord (*viz.* the ſtraight Line above-mentioned) of a Segment, and the Part of the Diameter intercepted between the Chord and the Arch, to find the whole Diameter.

As the intercepted Part of the Diameter to half the Chord, ſo the ſaid half Chord to the other Part of the Diameter; add them, and you have the Whole.

6. The Diameter and Circumference are as 7 and 22; ſet 7 to 22, againſt any Diameter is his Circumference; ſet 22 to 7, againſt any Circumference is his Diameter; or having ſet 7 to 22 againſt the Circumference on the ſecond is the Diameter on the firſt.

Sect. 7. *To reduce the aforeſaid Figures to Squares.*

Some of them, as the Triangle, long Square, *&c.* are reduced, as is ſhewn in the Meaſure of Timber of ſuch Baſes; the other, as alſo any irregular Figure, thus: Firſt find the ſuperficial Content, then ſet the ſquare Line to his Squares, as is before taught, againſt the ſuperficial Content on the Line of Numbers is the Side of the Square.

PROP. II.

Diviſion, wherein the Diviſor is the firſt Number.

Qu. 1. IF 32 Bricks pave one ſquare Yard, how many Yards will 500 Bricks pave? Set 32 to 500, or to 1, againſt the other is 15.6 Yards.

Qu. 2. If 25 Trees coſt 21*l.* what doth 1 Tree coſt? Set 25 to 21, being neareſt, againſt

1 is 0.84*l.* whereof the 8 is 16 Shillings, and the 4 is 9*d.* ½, as you will after ſee.

Qu. 3. The Content of a Rectangle or long Square being divided by one Side. (whether the longer or ſhorter) the Quotient is the other. Suppoſe 144 Men placed 24 in Front, how many deep do they ſtand? Set 24 to 144, againſt 1 is 6.

PROP. III.

Sect. 1. *The Rule of Three direct.*

WHEN the Length is meaſured in Feet, the Breadth in Inches, and yet the Content required in Feet, 12 is the firſt Number, marked as 12 on the ſquare Line, chiefly for the Meaſure of Plank, or Board, and Glaſs.

Qu. 1. A Plank is 36 ½ Foot long, 18 Inches broad; ſet 12 to either Length or Breadth, hereto 18, being neareſt, againſt 36 ½ is 54 ½ Foot.

Qu. 2. A Board is 14 Foot long, 26 Inches broad; ſet 12 to 14, againſt 26 is 30 ⅓ Foot.

Qu. 3. A Pane of Glaſs is 2 ¼ Foot long, 7.6 Inches broad; ſet 12 to 7.6, againſt 2 ¼ is 1.42 Foot, which .42 is almoſt an half.

Sect. 2. *Sawyers Meaſure.*

They account 120 to the Hundred. If you would know the Content of a Stock of Plank or Board in ſuch Meaſure; having found the Content of one Plank or Board by the Section aforegoing, ſet 120 (repreſented by 12) to the ſaid Content, or to the Number of Karſes or Cuts, (which are always leſs by one than the Number of whole Boards in the Stock) againſt the other are the Sawyers Hundreds, which will fall in the ſecond Length, except there be not

100 Foot in the Stock. The Tenths are each of them 12 Foot.

Example. Admit there were 22 Boards in the Stock mentioned *Qu.* 2. of the foregoing Section, the Content of one Board is 30 $\frac{1}{3}$; set 12 to 21, the Number of Karfes, against 31 $\frac{1}{3}$ is 5.31 near.

Which is 5 hundred and 37 Foot, for every Tenth, being, as is said, 12 Foot, if you set 10 to 12, against 31 is 37 and more.

Sect. 3. *Glass.*

It is most convenient in Glass to measure the Length as well as Breadth in Inches; yet the Content being required in Feet, 144 (represented by 14.4) is your first Number, and the Content, if a whole Foot, or above, in the second Length, as next before.

Example. A Pain of Glass is 31 $\frac{1}{2}$ Inches long, 8 $\frac{1}{2}$ broad, set 144 to 8 $\frac{1}{2}$, against 31 $\frac{1}{2}$ is 1.86 Foot.

Let there be 7 such Panes, set 1 to 1.86, against 7 is 13 Foot.

Sect. 4. *By the Yard.*

In the following Questions both Length and Breadth are to be measured in Foot Measure. If the Content be required in Yards, 9 is the first Number, there being 9 square Feet in a square Yard. So they measure Painting, Paving, Plaistering, Wainscot, *&c.*

Example. A Length is 24 Foot, the Breadth 10 $\frac{1}{2}$; set 9 to 10 $\frac{1}{2}$, against 24 is 28 Yards.

Sect. 5. *By the square of* 10 *Foot, as in Tiling, Flooring,* &c.

Here 100 is the first Number. A Roof is 41 Foot

Foot long, and the Sparr 20 ½ Foot; set 100 to 41, against 20 ½ is 8.4 Squares.

Sect. 6. *By the square Rod, at 16 ½ Foot to the Rod, as in Brick Walls.*

Here 272 ¼ (being the Square of 16 ½) is the first Number; also 272 being cut on these Rules, may serve without considerable Error. A Wall is 110 Foot long. 9 ½ Foot high; set 272 to 110, against 9 ½ is 3.83 Rod in the second Length. If you would have a Mark at 324, the Square of 18, set 18 to 10, against 18 on the second mark the Point.

Sect. 7. *By the Acre.*

In Land Measure 160 square Perches, Poles, or Rod (commonly at 16 ½ Foot, in some Places 18 Foot to the Pole) make an Acre, therefore 160 (represented by 16) is the first Number; the Parts are 40 Pole to the Rood or Quarter, 80 to 2 Roods, 120 to three; the Lengths and Breadths are measured in Poles.

Example 1. A Length is 35 Perches, the Breadth 19; set 160 to 19, against 35 is 4.15 Acres.

Example 2. A triangular Piece of Land hath the Base 24 Poles, the Perpendicular 16 ½; set 160 to 16 ½, against 12 (half the Base) is 1.24 Acre near; or set 320 to the Base 24. against the Perpendicular 16 ½ is 1.24, as before.

PROP. IV.

The inverse Rule.

HERE the Number that goeth with the Question is the first Number, which you may set to either of the other.

Example.

Example. It seems 272 $\frac{1}{4}$ Foot make a Rod of Brick Wall at only 1 $\frac{1}{2}$ Brick Thickneſs; if it be thicker, fewer Feet anſwer a Rod; if thinner, then more, at an inverſe Proportion.

If it be demanded how many Feet anſwer a Rod (for Example) at two Bricks Thickneſs:

Set 2 (which goeth with the Queſtion to 1 $\frac{1}{2}$, againſt 272 $\frac{1}{4}$ is about 204, *viz.* 204.18 Foot; and ſo for any other Thickneſs, which may be marked for firſt Numbers thus: ſet 1 $\frac{1}{2}$ to any Thickneſs, againſt 272 $\frac{1}{4}$ on the ſecond mark the Points.

PROP. V.

Fractions.

BY Fractions I mean Decimals; a general Rule for them is: Set 10 or 100 to the Number of Parts (that make the Whole) in the Queſtion, againſt every Decimal is its own Share or Portion of the ſaid Parts.

Sect. 1. *Of a Pound Sterling.*

The firſt Figure after the Prick in any Decimal of a Pound, is ſo many two Shillings, double it therefore, and you have the Shillings anſwering; 5 in the next Place is one Shilling: theſe being accounted, ſet 100 to 24, againſt the remaining Decimal are the Pence; if there be not 5 in the ſecond Place, having ſet as above, againſt the other is the Pence, the Farthings being very eaſily eſtimated on the Rule.

Example. Let 688 be the Decimal, the 6 is 12*s.* and 5 in the next 8 is 1*s.* ſet 100 to 24, againſt 38, the remaining Decimal, is 9*d.* in all 13*s.* 9*d.*

Or without the Rule thus: Having taken out the Shillings, as above, if the remaining Decimal

mal exceed not 30, account them Farthings, abating one; if it exceed 30, take 25 out of it, which is 6*d.* and the Remainder account Farthings, abating one.

Note, That the Decimal is ſuppoſed of three Places at leaſt; if it be but of two, ſuppoſe a Cypher for the third; and if there be more, you may neglect them, with the Caution in the like Caſe before given.

So taking .25 out of .38, (in the Example above) the remaining 13 account 12 Farthings, or 3*d.* ſo the whole is 9*d.*

Sect. 2. *Of a Rod.*

At 30*s.* the Rod, what are 28 Cents? Set 100 to 30, againſt 28 is 8.4, *viz.* 8*s.* and 4 Tenths; ſet 10 to 12, againſt 4 is 4*d.* $\frac{3}{4}$; in all 8*s.* 4*d.* $\frac{3}{4}$.

Sect. 3. *Of an Acre.*

How many Perches are 15 Cents of an Acre? Set 100 to 160, againſt 15 are 24 Perches. More Examples are needleſs.

Sect. 4. *Vulgar Fractions into known Parts.*

Set the Denominator, being the lower, to his Numerator, againſt the Number of known Parts in the Whole is the Number of Parts required; or ſet the Denominator to the Number of Parts, againſt any Numerator is his Portion of the ſaid Parts.

How many Farthings are $\frac{5}{7}$ of a Shilling? Set 7 to 48, againſt 5 is 34, or 8*d.* 2 Farthings.

Sect.

Sect. 5. *Vulgar Fractions into Decimals.*

Set the Denominator to his Numerator, against 100 is the Decimal required. What Decimal of a Foot is $\frac{7}{12}$ or 7 Inches? Set 12 to 7, against 100 is .58 near enough, or .583.

The aforegoing Examples being well understood, it will not be difficult to apply the double Scale to any other Subject.

PART V.

SECTION I.

The diagonal Scale. (Fig. III.)

IT consisteth of 21 equidistant parallel Lines through the Length of the Scale, and of transverse Parallels at a Quarter of an Inch Distance one from the other, with 5 Diagonals through the uppermost Integer. In the Parallel of 10 there is a Cypher at every Transverse. This Row of Cyphers divides the whole Scale into two Scales, having one diagonal Integer over both.

It is fitted chiefly to *Gunter*'s Chain, which is accounted the best for surveying of Land, and is of 16 Perches in the Inch.

If the Place of Tens in the Link be 0, 2, 4, 6, or 8, (the last four whereof are set against their respective Diagonals) use the first or left Hand Scale; but if the Place of Tens be 1, 3, 5, 7, or 9, use the second or Right Hand Scale; for that Diagonal which is 20 (for Example)

in the firſt, is 30 in the ſecond; that which is 40 in the firſt, is 50 in the ſecond, &c.

Example 1. Let 10 Chains and 46 Links be required from the Scale, ſet one Foot of the Compaſſes on the long Parallel or Link Line, repreſenting 6 in the 10th Chain Line or Tranſverſe, and firſt Scale, and extend the other to the Diagonal 40 in the ſaid Link Line of 6.

2. But to take off 10 Chains and 56 Links, ſet one Foot on the Link Line of 6 in the ſaid tenth Chain Line, and ſecond Scale, and extend the other to the ſame Diagonal in the ſaid Link Line of 6, ſo have you the Lines required.

3. So having a Line on your Plot, to know how many Chains and Links it is, take it with your Compaſſes, and carry it parallel to the Link Lines, one Foot in one of the Chain Lines, and the other through the diagonal Integer, till it falls on one of the Diagonals, and according as it falls in the firſt or ſecond Scale, ſo account the Tens of your Links.

The Scale may be made to 20 in the Inch, (as it is commonly to 12, and ſet on the other Side) which muſt needs exceed any plain Scale of that Dimenſions for Exactneſs.

SECT. II.

Gunter's Chain.

IT is 4 Perches long, at 16 ½ Foot to the Perch, theſe make 792 Inches; it hath 100 Links, ſo each Link is 7.92 Inches.

Theſe Chains are diſtinguiſhed with Pieces of Braſs at every tenth Link, which Pieces contain ſo many Corners or Points as they are Tens of Links diſtant from either End of the Chain: thus, That

That Braſs at 10 Links has one Tippet or Point, that at 20 has two, that at 30, three; that at 40, four; and the ſame again from the other End; but at 50, the Middle, is a large round Piece of Braſs; and at 25, from each End, two Curtain Rings together. By the Help of theſe Diſtinctions (which are plainer, and far more viſible than the old Way of Rings alone) you will ſpeedily find the Number of Links.

Although the Chains be divided into 4 Perches by the two double Rings and the large Braſs Circle in the Middle, ſo that it may be applied to the Meaſure of any Length by the Pole, yet in meaſuring Lengths in ſurveying we take Notice only of Chains and Links, not concerning ourſelves with Perches till we caſt up the Content.

To multiply a Length and Breadth meaſured with this Chain, reduce them into Links, which is no more Trouble than to ſet the Links at the right Hand of the Chains; or if there be no Links, to put two Cyphers there; ſo 4 Chains and 32 Links are 432 Links, and 7 Chains are 700 Links, 10 Chains and 6 Links are 1006 Links.

Having multiplied a Length by a Breadth, the ſixth Figure of the Product to the Left Hand (if there be ſo many) is Acres compleat, the ſeventh Tens of Acres.

Example 1. If you multiply 5 Chains and 82 Links by 3 Chains and 21 Links, the Product is 1.86822, whereof the 1 is one Acre.

Ex. 1.

$$
\begin{array}{r}
582 \\
321 \\
\hline
582 \\
1164 \\
1.746
\end{array}
$$

Also 13 Chains and 42 Links by 8 Chains and 70 Links, the Product is 11.67540, whereof the 11 is eleven Acres. The Decimals are reduced to Roods and Perches as followeth.

Ex. 2.	13.42
	870
	93940
	10736
	11.67540

SECT. III.

To reduce the Decimal Lines of Gunter's *Chain into Poles.*

AN Acre is 160 ſquare Perches, as hath been ſaid, equal to 100,000 ſquare Links of this Chain, which being divided by 160, the Quotient 625 is the ſquare Links of 1 Perch or Pole; this, as it is the Decimal of an Acre, ought to be expreſſed thus .00625, alſo all other, *viz.* with 5 Places, except it be even Tens, for a Cypher or Cyphers at the left Hand are of no Value, as hath been ſaid.

The Parts of an Acre are firſt 4 Roods, whereof 4 is your firſt Multiplier, and there being 40 Pole in a Rood, 40 is your ſecond.

Or if you multiply your Decimal by 160, the Figures remaining to the left Hand, after the Decimal be cut off, are Perches immediately.

But where the Content is not exacted to half a Pole, we uſually take this ſhorter Courſe, without prefixing Cyphers.

It is evident, that if the Places of the Decimal be but three, there cannot be two Poles; if they be four, multiply the firſt Figure by 6; if five, multiply the two firſt Places by 6, in both ſet the Product one Place back toward the right Hand, then add together the firſt, or two firſt Places

(reſpectively)

(respectively) of the Decimal and Product so set, adding also a Unit for every 6 that shall be in the Figures of the next Place, the Sum is the Number of Poles in the Decimal.

See here two Examples, one of 4 Places, the other of five; also you see how the Products are placed and added.

Ex. 1.	*Links*	8172
		48
	Poles	13

In the first there is once 6, in the second twice 6, in the Figures of the next Place, for which 1 in the first, and 2 in the second, are added to the other; the two Places to the right Hand are neglected, as never amounting to the sixth Part of a Pole.

Ex. 2.	*Links*	21726
		126
	Poles	35

The Reason of this Operation, Mr *Wingate* (in whose Arithmetick I first met with it, used also by Mr *Atwell*, as you may see in his Book of Surveying, printed *Anno* 1662, which I value beyond most Books of that Subject printed since) deeming it not very obvious, leaves to the Search of the Curious. Take it here:

1. If 100 (which are so many thousand square Links, being an Acre) requires 60 to be added to it to make it 160 Poles, being also an Acre, what shall any other Number of thousands of square Links require to be added to it to turn it into Poles?

2. To multiply a Number by 6, and divide the Product by 10, gives the same Quotient which you have by multiplying the same Number by 60, and dividing the Product by 100.

3. Setting the Product a Place back to the right

right Hand, both divides by 10, and ſeats it for Addition.

SECT. IV.

A ready and exact Way by the Rule.

ON the double Scale ſet 100 to 16, againſt the Links are the Poles anſwering; neglect the two laſt Figures, as is ſaid.

If the Decimal be 60,000, or more, take 5 out of the firſt Figure, accounting for it 2 Roods, and find the Poles anſwering the Remainder; let the Decimal be .82511; deducting 5, the Remainder is .32511; ſet 100 to 16, againſt .325 is 52, *viz.* 1 Rood and 12 Pole; ſo the Decimal is 3 Rood 12 Pole.

SECT. V.

Having the three Sides of a Right-lined Triangle, to find the ſuperficial Content.

ADD the three Sides together; from half the Sum ſubtract each Side ſeverally, ſo you have three Remainders; multiply theſe three and the half Sum continually, that is, the firſt Remainder by the ſecond, the Product by the third, and this Product by the half Sum, the ſquare Root of this laſt Product is the ſuperficial Content.

Moſt eaſily and ſpeedily by the Logs. thus: Add the Logs. of the three Remainders and the half Sum together, half the Sum is the Log. of the ſuperficial Content.

Example.

Example. Let the Sides be 1050, 854, 774, the half Sum is 1339, the three Remains 289, 485, 565, the Content is 3 Acres, 1 Rood, and 1 Perch near: This is the most certain Way of measuring Land, where the Triangles can be measured in the Field; which otherwise are first plotted on Paper, and the Length of

1339	3.12678
289	2.46090
485	2.68574
565	2.75205
a.	11.02547
3.25640	5.51273
150	*a. r. p.*
41	3.1.01 *near*

the Base and Perpendicular of every Triangle measured upon the plotting Scale, and from them the Content cast up, as has been shewn before: Not but there are Methods by which you may cast up the Content of Lands, though ever so irregular, without plotting, and that to the greatest Truth imaginable, as being grounded upon a Theory as true as any Proposition in *Euclid*, and where the utmost Exactness possible is required, is doubtless the best Way.

Here

Here follows the Description of the other Side of the Rule, which is applied to find Lengths and Angles of Hips, Rafters, and Collar-Beams, whether the Roof be square or bevelling, and that at any Pitch.

FIRST then, on the innermost Edge of each Leg or Joint of the Rule, is drawn a Line from the Center, numbered 2, 3, 4, 5, 6, and so on to 15, whose Use is to divide a Circle into any Number of equal Parts not exceeding 15.

Next to these Lines on each Joint is drawn another Line, which is divided into 30 equal Parts representing so many Feet, each Foot being divided into 12 equal Parts to express the Inches.

There is on one of the Legs a Line divided into 40 equal Parts, of the same Length with the 30 Scale, which also represents Feet, each Foot being divided into 6 equal Parts, and therefore each Division is 2 Inches.

On the other Leg, next the 30 Scale, is a Line of Chords, numbered in 10, 20, 30, and so on to 180, each of which Parts are divided into 10 more, to express each single Degree, whose

whose Use is to find the Quantity of an Angle in Degrees and Minutes.

Before we proceed to the Use of these Lines, it will not be improper to explain what is meant by the Terms Lateral and Parallel.

First, By the word Lateral is meant any Distance taken in a straight Line from the Center, either upon the 30 or 40 Scale, or upon the Line of Chords.

For Instance, suppose I would take 20 Feet laterally off of the 30 Scale, fix one Point of the Compasses in the Center, and extend the other to 20 on the 30 Scale of either Leg, and the said Extent is called a lateral Extent of 20 Feet. And so for any other.

2. By a parallel Extent, we mean any Distance taken by extending the Compasses from any Number of Feet and Inches on the 30 Scale of either Leg, to the like or unlike Number on the 30 Scale of the other Leg, as thus: The Rule being any how opened, the Compasses extended from 25 on one Leg to 25 on the other, is a parallel Extent of 25 Feet; but if it had been extended from 25 on one Leg, to any other Number more or less on the other Leg, it is still called a parallel Extent.

3. When one Point of the Compasses is fixed in a given Point, and the other so opened or shut as just to touch a given Line, that Extent is called the nearest Distance between the said Point and Line.

4. *How*

4. *How to represent any Number of Feet and Inches by a right Line.*

Extend the Compaſſes laterally from the Center on the 30 or 40 Scale to the Number propoſed, and that is the Length of the Line required.

5. But if theſe Scales are too great or ſmall; for Inſtance, ſuppoſe you wanted a Line of 4 Inches to be divided into 30 equal Parts, or, which is the ſame Thing, to have a Line of 4 Inches repreſent 30 Feet; proceed thus:

Take 4 Inches between your Compaſſes from off the Scale of Inches, and make the ſaid Extent a Parallel in 30 and 30, and thus the 30 Scale is ſet to your Deſire.

6. *To ſet the 30 Scales ſquare.*

Take 90 from off the Line of Chords with your Compaſſes, and make the ſaid Extent a Parallel in 15 and 15 of the 30 Scales, and then the ſaid Scales are ſet ſquare or perpendicular to each other.

After which ſhort Deſcription and Uſe of *Scamozzi*'s Lines, let us apply them to that Part of Building, where the Length of Hips, Rafters, and Angles are concerned, whether the Frames be ſquare or bevelling, *&c.*

PROP. I.

LET ABCD, in *Fig.* I. repreſent the Frame of a Houſe bevelling at one End and ſquare

at the other, the Gable End being ſquare, and the Bevel hipt.

In which A B is 11 Feet, B C 14 Feet 5 Inches, C D 9 Feet 6 Inches, and A D 20 Feet; and having drawn the Poſition of the Frame according to theſe Lengths, draw the Gable End D E C, whoſe Rafters D E and C E are each equal to three Fourths of the Breadth of the Houſe C D; biſect or divide the Lines A B and C D into two equal Parts in the Points G and F, and draw the Line F G for the Ridge of the Houſe; and E F, the common Perpendicular, will repreſent the Height thereof above the Floor.

Next, make G H equal to B G or G A, and through the Point H draw the Diagonal A I and B I, which will ever interſect each other at right Angles; and then through H draw the Lines P S and *m n*, the former perpendicular to F G, and the latter parallel to A B.

To find the Length of the Hips.

Make H I equal to E F (5 Feet 4 Inches) the Height of the Rafters perpendicular, and draw the Lines A I and B I for the two Hips, A I in this Caſe being the longeſt, and B I the ſhorteſt; which being raiſed to their proper Pitch, will meet the principal Rafters K P and L S perpendicular to the Point H.

To find the Back of the Hips, ſo that it may anſwer both Sides and Ends of the Roof.

Lay the Ruler from C to *n* and from G to *m*, and interſect the Diagonals H B and H A in the

the Points *u* and *w*; then with one Point of the Compaſſes fixed in the Point *u*, with the other take the neareſt Diſtance to the Hip B I, and lay it off from *u* to M, and drawing the Lines *n* M, M G, they will form the Angle *n* M G, equal 137°, for the Back of the leſſer Hip B I.

Alſo, if with one Point of the Compaſſes fixed in the Point *w*, you take the neareſt Diſtance to the Hip A I, and lay it off from *w* to M, and draw the Lines *m* M, M G, you will have the Angle *m* M G, equal 99°, for the Back of the longeſt Hip A I.

And if you make K P, D Q, L S, and C R, each equal to the Rafters C E or D E, and join the Points Q P and S R, they will be the Length of the Ridge of the Roof, each being equal to F H. Now, if to P K or D Q, and to L S or C R, you draw Lines parallel, about 12 or 14 Inches diſtant from each other, at which Diſtance it ſeems Rafters ſtand, and allowing for their Breadth, you will have them repreſented to your View as they lie in Ledgment; alſo if A N and B N (equal to the Hip Rafters A P and B S) are drawn, they will appear juſt in the ſame Manner as when they lie in Ledgment.

With the Rule to find the Length of the Rafters by Inſpection, when true Pitch.

Againſt 9 Feet 6 Inches (the Breadth of the Houſe) upon the 40 Scale is 7 Feet 1 $\frac{1}{2}$ Inches upon the 30 Scale, for the Length of the Rafter; alſo againſt 7 Feet 1 $\frac{1}{2}$ Inches upon the 40 Scale,

Scale, is 5 Feet 4 Inches upon the 30 Scale, for the Length of the Rafters perpendicular, or Height of the Ridge above the Floor.

But if the perpendicular Height of the Gable End ſhould be agreed on, and by that means the Roof be above or under true Pitch, then open the Rule, ſo that the 30 Scales may ſtand perpendicular to each other, and count half the Breadth of the Houſe upon one Leg from the Center, and the Height of the Perpendicular upon the other, *viz.* both upon the 30 Scales, and the parallel Diſtance between them meaſured laterally upon the 30 Scale, will give the Length of the Rafters.

EXAMPLE.

Suppoſe the Breadth of a Houſe be 35 Feet, and the perpendicular Height of the Gable End 23, then working as above directed, you will find the Length of the Rafter to be 28 Feet 10 Inches.

It is doubtleſs of great Uſe to know what Angles the Rafters make at Foot and Head, with the raiſing Piece and the King's Poſt, and of the Angles made at the Foot and Top of the Hips, and therefore I ſhall give one general Rule to meaſure any Angle.

Always take the Length of thoſe Lines which contain the Angle you would meaſure, and count them from the Center on the 30 Scales, and ſo open or ſhut the Rule, that the parallel Diſtance between them may be equal to the Side oppoſite to the required Angle, taken laterally off from the 30 Scale by a Pair of Compaſſes; and

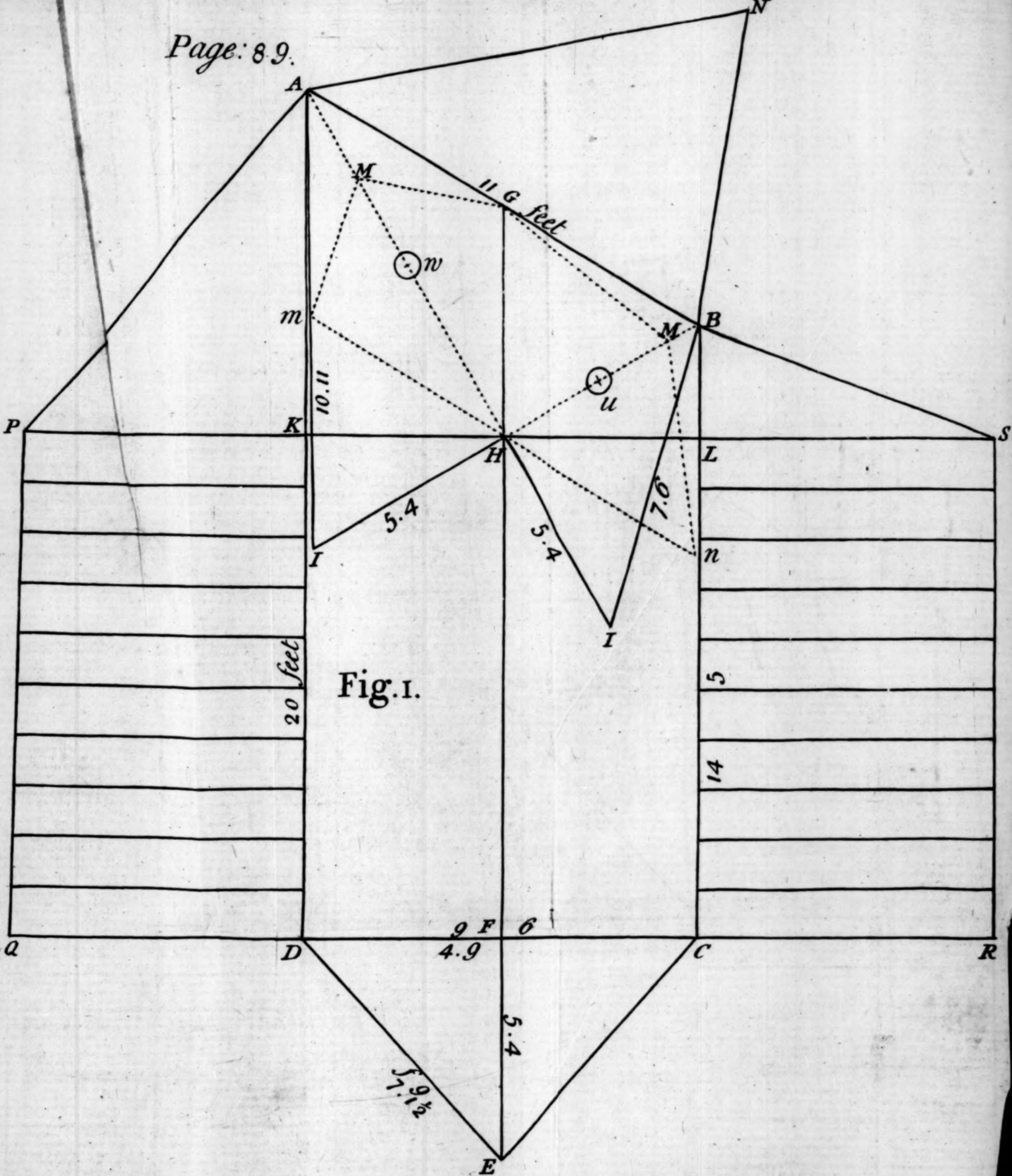

N
A
M
11 G feet
w
m
B
M
u
10.11
P
K
H
S
L
5.4
7.6
5.4
I
n
I
feet
20
5
14
9 F 6
Q
D
4.9
C
R
5.4
f 9½
7.1½
E

Fig. I.

and then if the parallel Diſtance between 15 and 15 be meaſured upon the Line of Chords, it will ſhew the Degrees and Minutes of the Angle.

EXAMPLE.

Suppoſe it was required to meaſure the Angle D E F, *viz.* the Angle made by the Rafter D E, and its perpendicular Height E F.

Firſt, I take the lateral Extent of 4 Feet 9 Inches in my Compaſſes off of the 30 Scale, which is the Side oppoſite to the Angle ſought, then apply it parallel, by fixing one Point of the Compaſſes in 5 Feet and four Inches on the 30 Scale of either Leg, and ſo open or ſhut the Rule, that the other Point of the Compaſs may reſt upon 7 Feet 1 ½ Inches on the 30 Scale of the other Leg; and then taking the Diſtance with your Compaſſes between 15 and 15, and meaſuring it laterally upon the Line of Chords, the Quantity of the Angle ſought will appear to be 41 Degrees 50 Minutes, which ſubtract from 90 Degrees, and there will remain 48 Degrees 10 Minutes for the Angle F D E at the Foot of the Rafter.

Or the Angle D E F may be meaſured thus: Lay the innermoſt Edge of either Leg juſt to touch the Line E F, the angular Point E being as near to the Center of the Rule as poſſible for the Braſs Joint; then ſo open or ſhut the other Leg of the Rule, that it may remain parallel to the Line DE, and the parallel Diſtance between the two little Lines drawn upon the inner Edges of the Rule at 15 and 15, meaſured upon the

Line of Chords, will give the Degrees and Minutes of the Angle, equal 41 Degrees and 5 Minutes, as before.

And after this Manner the Angle at the Back of the Hips may be taken with a Bevel, and ſerve in Practice, as well as if taken by the Rule, and the Degrees and Minutes of the Angle determined.

PROP. II.

To find the Rafters, Hips, and Angles of Bevel and Taper Frames.

IN theſe Sort of Frames obſerve, that the Middle Breadth is the Guide for the Rafters Length, and that the Perpendicular at both Ends muſt be equal to the middle Rafters Perpendicular, to prevent the Roof's being higher in one Place than another; for though a Pair of Rafters at one End of the Houſe will exceed the Length of a Pair at the other, yet, becauſe they and the reſt of the Rafters are proportioned by a common Perpendicular, all Parts of the Roof will be of an equal Height.

In *Fig*. II. Let ABCD repreſent ſuch a Frame, in which, beſides knowing the Lengths of the 4 Sides, it is neceſſary that one of the Angles ſhould be given, in order to lay down the Frame in its true Poſition; for if one of the Angles be not determined, there may with the ſame 4 right Lines be conſtituted an infinite Number of Figures, and all different in Area and Form from one another: Wherefore let the Angle D A B be 70 Degrees.

And then to deſcribe the Frame, having drawn the

the Line A D equal to 26 Feet, proceed to lay down the Angle D A B and the Side A B, after this Manner; take 70 Degrees, the Quantity of the Angle D A B, laterally off with your Compaſſes from the Line of Chords, and make the ſaid Diſtance a Parallel between 15 and 15; and then fixing one Point of the Compaſſes in 26 (on the 30 Scale of either Leg) which is the Length of the Side A D, extend the other to 11 Feet 9 Inches on the 30 Scale of the other Leg; and with this Extent, one Foot of the Compaſſes being fixed in the Point D, with the other deſcribe the ſmall Arch *r* B *s*; and then taking 11 Feet 9 Inches between your Compaſſes, and fixing one Point in A, with the other deſcribe the Arch *u* B *w*, and where the Arches interſect each other as in B, draw the Line A B, and ſo ſhall the Line A B be laid down according to its true Length and Poſition: And ſince the Points D and B are known, it will be eaſy to determine the Point C by the Length of the Lines D C and B C, which are alſo given, C D being 9 Feet 6 Inches, and B C 18 Feet 10 Inches.

Next divide D C into two equal Parts in the Point Z, and A B in the Point G, and having drawn the Line Z G which repreſents the Place over which the Ridge of the Houſe muſt ſtand, make G I equal to B G or A G, and Z F equal to D Z or Z C; and through the Point I, draw the Diagonals A *m* and B *k*, which will always interſect each other at right Angles, though the Frame bevel and taper ever ſo much, as may eaſily be proved from the Elements of *Euclid*: Alſo thro' the Point F draw the Diagonals D *n* and C *h*.

Croſs

Crofs ZG in the Middle at right Angles, as *y x*, which middle Breadth being upon Trial found to meafure 10 Feet, three Fourths thereof, *viz.* 7 Feet and a half, will be the Length of the Rafter *b c:* And again, three Fourths of the Rafters will produce 5 Feet 7 $\frac{1}{2}$ Inches for the Rafter's Perpendicular, or Height of the Ridge all over the Frame. This may be done by Infpection by the 30 and 40 Scales on the Rule.

Which being either Way determined, let us proceed to find the Length of the Hips.

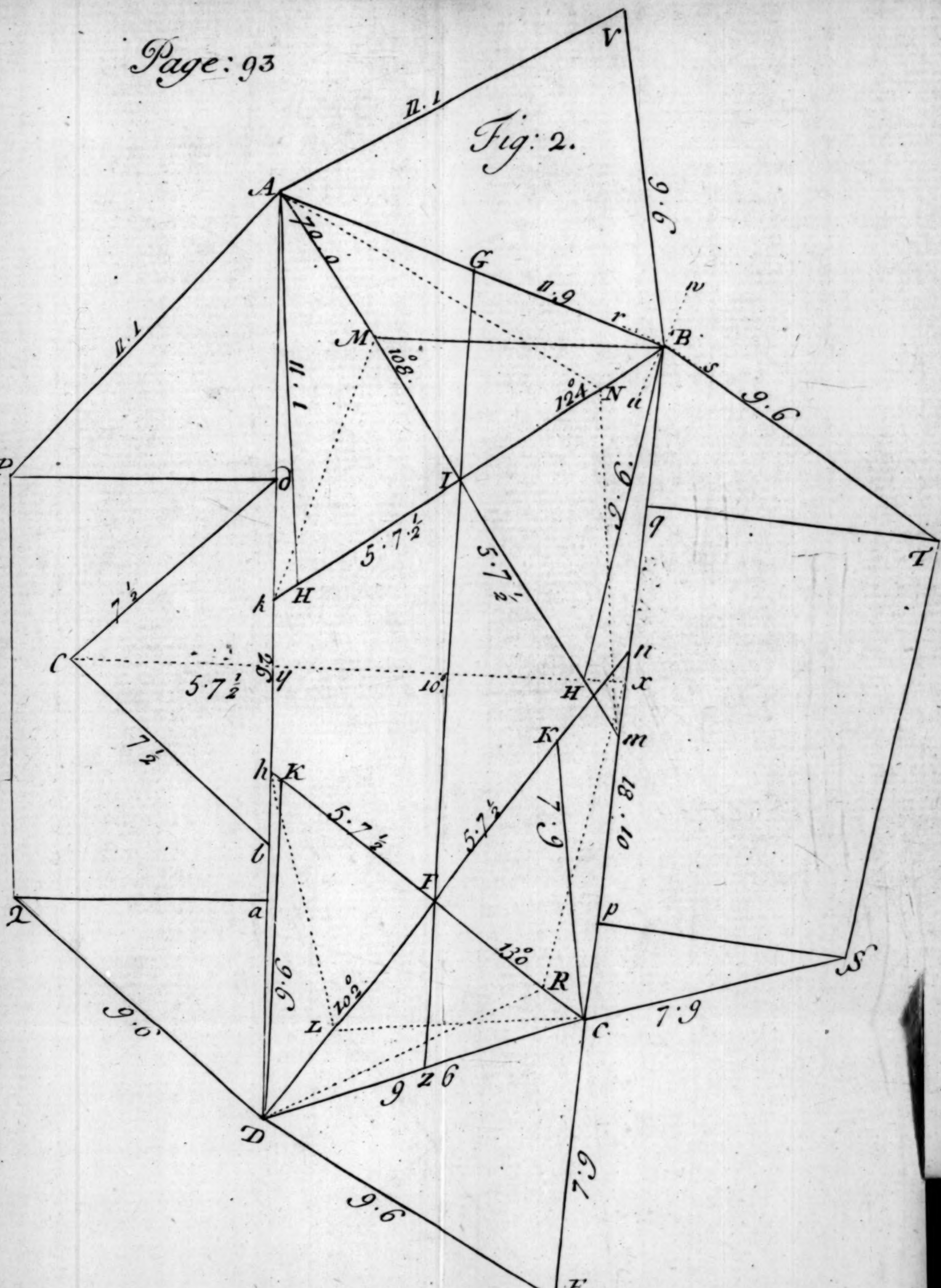
Firft then, becaufe AI and BI reprefent the Diftance of the King's Poft, or Point over which the Hips will ftand, when raifed to their proper Places from the two Corners of the Frame A and B, and that the IH's are perpendicular to the faid Diftances AI and BI, and both equal to 5 Feet 7 $\frac{1}{2}$ Inches, the perpendicular Height common to all the Rafters.

I fay, if you draw the Lines AH and BH, it is evident they will reprefent the two Hips at that End of the Houfe expreffed by the Letters AGB, the greater Hip AH being 11 Feet and 1 Inch, and the lefs BH 9 Feet 6 Inches.

Moreover, if FK be made equal to *yc* 5 Feet 7 $\frac{1}{2}$ Inches, and DK and CK drawn, they will, by being meafured upon the 30 Scale, fhew the Length of the Hips at the other End of the Houfe, *viz.* DK the greater Hip 9 Feet 6 Inches, and CK the lefs 7 Feet 9 Inches.

To

Fig: 2.



To find the Angles for the Back of the Hips.

In order to which, fix one Point of the Compasses in I, the Foot of the King's Post, and with the other take the nearest Distance to the Hips A H and B H, laying off the former Distance from I to M, and the latter from I to N, and drawing the Lines *k* M, M B and A N, N *m*, the Angle *k* M B will be 108 Degrees for the Back of the longest Hip A H, and the Angle A N *m* 124 Degrees for the Back of the lesser Hip B H.

The Quantity of these Angles is found by the general Rule; as delivered before for measuring of all right-lined Angles.

To represent the Breadth and Length of each Side of the Roof, raise two Perpendiculars, *viz.* *a* Q and *d* P from the raising Piece A D; and so that, if continued both ways, they may pass through the Points I and F; and then lay the Length of the Hip A H from A to P, and of D K from D to Q, and draw the Lines D Q, Q P, and P A, for one Side of the Roof.

Then make *q* T and *p* S perpendicular to the raising Piece B C, and so that they may likewise pass through the Points I and F; then lay the Length of the Hip B H from B to T, and of C K from C to S, and join the Points C, S, T, and B, by drawing the Lines CS, S T, T B, which will form the Shape of the other Side of the Roof; and as Q P and S T are each equal to F I, the Distance

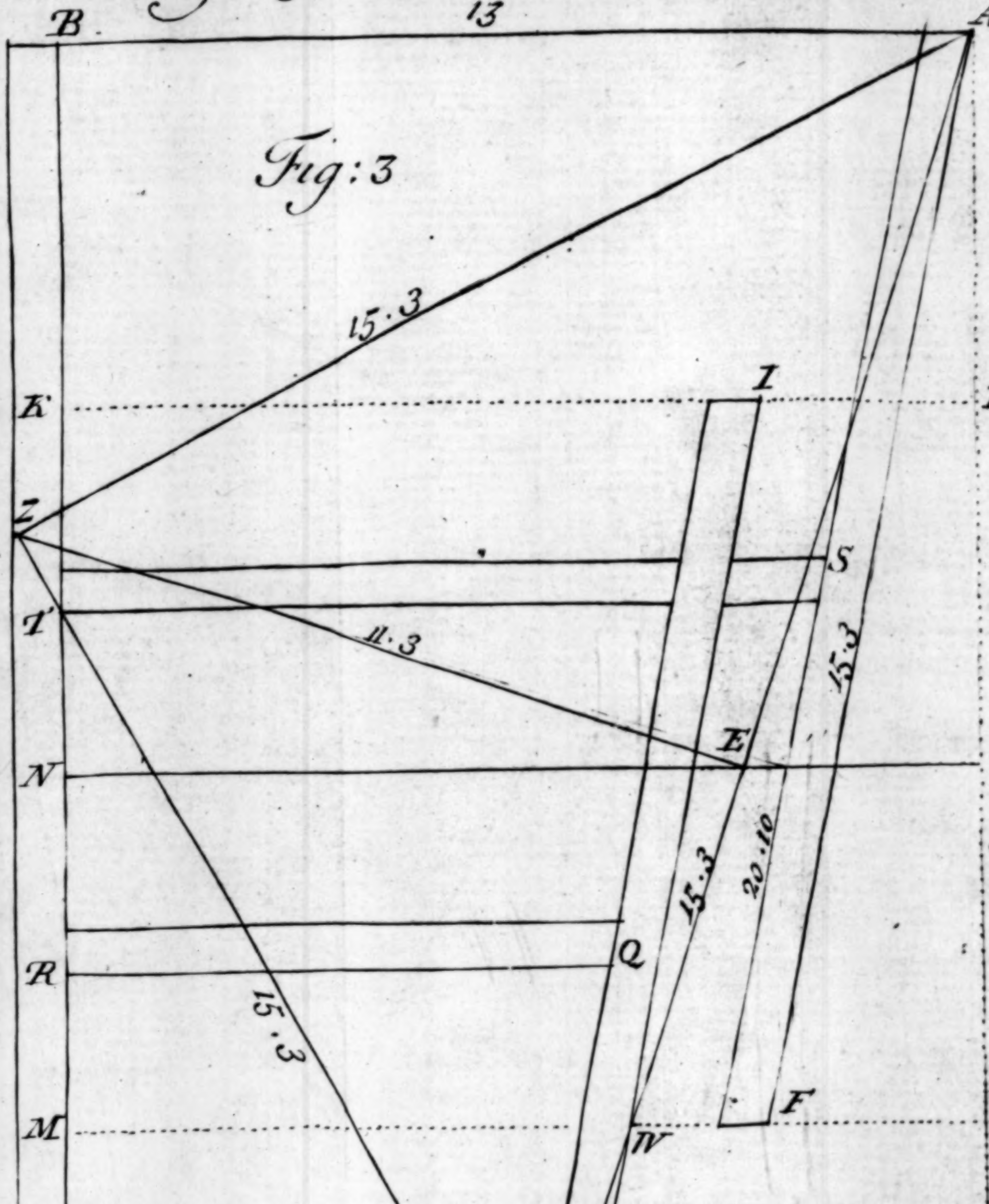
tance between the King's Posts, so when they are turned over to meet in their proper Places, will represent the Ridge of the House; and if ABV, the greater Hip, and DCE, the less, be turned over to their respective Places, the Point V will meet the Points P and T, and be perpendicular to the Point I; and the Point E will meet the Points Q and S, and be perpendicular or right over the Point F.

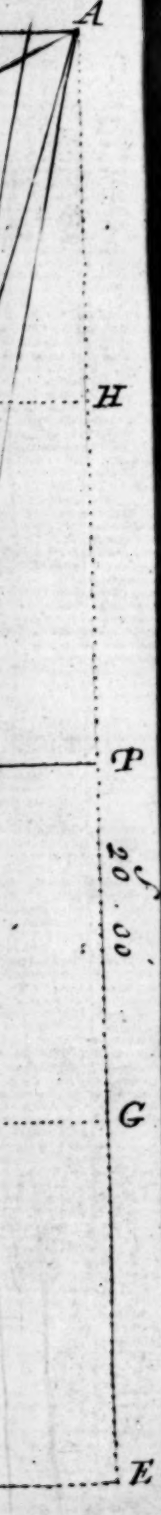
To find the Lengths and Angles of Collar-Beams in any Roof.

After having taken the whole Breadth of the Frame between your Compasses, set one Point thereof in the Length of the Rafter on the 30 Scale of either Leg, and let the other Point rest in the Length of the Rafter, counted upon the 30 Scale of the other Leg, which two Legs represent the two principal Rafters; and a Rule being laid from one Point of the Compasses to the other, represents the raising Piece; then at any Height you design the Collar Beam shall be above the raising Piece, if you apply a Ruler parallel to it, the Distance between the Rafters is the Length of the Collar-Beam, (allowing spare Wood for the Tenons) which Distance you must measure laterally from the Center on the 30 Scale; and as for the Angles to cut the Tenons by, they are the same as the Rafters make at Foot with the raising Piece.

PROP.

Page: 95





PROP. III.

To find the Lengths and Angles of Rafters and Purloins in Bevel Frames.

IN *Fig.* III. let ABCD be a Frame bevelling at one End, and ſquare at the other: Firſt, The Length of the Lines or Sides of the Frame being determined, it will be eaſy (by what has been already ſaid) to lay it down in its true Poſition; which being done, draw AE parallel to BC, and produce CD to E; biſect or divide BC and AE into two equal Parts at the Points N and P; and draw NP for the middle Line of the Frame, and draw KH in the Middle between AB and NP, and MG in the Middle between NP and CE; and ſo will CK and BM repreſent the Length of a ſquare Pair of Rafters, each being three Fourths of the Breadth of the Frame BC, therefore equal to 15 Feet; three Fourths of which is 11 Feet 3 Inches, the Length of the Perpendicular common to all the Rafters.

Next, make FG and IH each equal to EP, and draw the Lines DI and AF, which will repreſent the Outſide Lines of the bevel End Rafters, and the Lines parallel to them the Inſide, as being drawn according to the Breadth or Scantling of the Rafters, which here is 8 Inches.

Thus the Lines AF and DI repreſent the bevel End Rafters, laid in Ledgment to fit in the Purloins,

Purloins, they lying out of Square according to the Angles GAF and CDI, the one being 11° 20′ leſs than 90°, and the other 11° 20′ more than 90°; which Angles alſo repreſent the Back of the Raſters at the Foot.

And as CK and BM repreſents a Pair of ſquare Raſters, at ſome intended Diſtance from A; ſo TS and RQ will repreſent the true Length of the Purloins fit for thoſe Places, RQ being the ſhorteſt, and TS the longeſt.

And as for meaſuring of them, and finding the Angles, which the Workman may think neceſſary in his Practice of Building, they are performed in all Reſpects, as has been before deſcribed in the precedent Schemes; I therefore thought it needleſs to repeat them again, but choſe rather to leave the Operations to the Reader's own Application, and ſo conclude.

FINIS.